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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 485

A GEOLOGIC RECONNAISSANCE
OF THE
ILIAMNA REGION, ALASKA

BY

G. C. MARTIN AND F. J. KATZ

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PREFACE.

By Alfred H. Brooks.

Even during the Russian occupation of Alaska the journeys of traders and a few explorers had determined the position of the larger geographic features of the southern part of the region described in this volume. Since then this knowledge has been augmented by two expeditions organized for exploration and by the journeys of traders and prospectors. In this way a general knowledge of the relief and drainage of the province was obtained as well as some idea of its mineral resources. Previous to 1909, however, when the surveys whose results are here presented were made, accurate maps and knowledge of the geology and the distribution and occurrence of the mineral resources of the Iliamna region, except for the shores of Cook Inlet, were almost entirely lacking.

The Geological Survey's general plan for the investigation of the mineral resources of Alaska provides for reconnaissance geologic and topographic surveys of the Territory. Naturally the areas of proved economic importance have been taken up first, and this accounts for the long delay in surveying the Iliamna region, in which there has been no mineral production. Copper and gold lode prospects have been found within the district, some of which may prove to have commercial value. Relatively little work has been done on these prospects, so that it is not possible to give a definite opinion of the commercial importance of any of them.

The report is based on about four months of field work. During this time the two topographers of the party mapped 5,150 square miles, including the area of the lakes, and the two geologists 3,000 square miles. The topographic work is accurate to the scale, and much of the geologic mapping was done to a greater degree of refinement than has usually been possible in rapid reconnaissance surveys. Surveys made in 1903 and 1904 along the west shore of Cook Inlet were utilized to extend the mapped area to the east.

The matter presented in this volume is of importance not only because it describes a field new to the geologist, but also because it contributes many facts that will help elucidate the stratigraphy and structure of adjacent fields. The considerable detail in which the Mesozoic sequence has been determined is worthy of special note. Of importance to the miner are the facts set forth that the copper lodes occur in metamorphic limestones near the contacts of intrusive rocks and that the auriferous quartz veins thus far discovered occur either in greenstones or in granites.

This report covers an area lying between the Mount McKinley region on the north, which has already been described,[1] and the Alaska Peninsula, the general features of the geology and mineral resources of which have been summarized.[2] Some progress has been made in this volume in correlating the geology of these two regions, but much remains to be done before definite statements can be made concerning the stratigraphic equivalency of their geologic formations. There still remains a large area lying between Lake Clark on the south and the Rainy Pass region of the Alaska Range on the north which is almost entirely unexplored and which should, therefore, be surveyed.

Of possibly greater commercial importance would be a survey of the basin of Mulchatna River, lying west of the area here discussed. Auriferous gravels have been found within this basin, some of which are reported to carry sufficient gold to warrant exploitation, and a survey of this field will be undertaken as soon as circumstances permit.

---

[1] Brooks, A. H., The Mount McKinley region, Alaska: Prof. Paper U. S. Geol. Survey No. 70, 1911.

[2] Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: Bull. U. S. Geol. Survey No. 467, 1911.

A GEOLOGIC RECONNAISSANCE OF THE ILIAMNA REGION, ALASKA.

By G. C. MARTIN and F. J. KATZ.

INTRODUCTION.

LOCATION.

The region described in this report covers an area of about 5,150 square miles. It is situated, as is shown on figure 1 (p. 12), in southwestern Alaska, west of the southern half of Cook Inlet and north of the Alaska Peninsula. It comprises the greater part of the drainage basins of Kvichak River, which is the outlet of Iliamna and Clark lakes flowing into Bristol Bay, and of the streams flowing into Cook Inlet from the west, south of and including Tuxedni Bay. The extreme limits of this area are bounded by parallels 59° and 60° 30′ N. and meridians 152° 30′ and 157° W. The nearest large town is Seward, which is about 150 miles to the east.

GEOGRAPHIC FEATURES.

TOPOGRAPHY.

Most of the northeastern part of this region lies within the Chigmit Mountains and consists of high, rugged mountain masses and narrow intervening valleys. The general elevation of these mountains is from 4,000 to 6,000 feet, although many peaks near the north end of Lake Clark are 7,000 feet high and the highest peak of the whole district is Mount Iliamna, which is about 10,000 feet high. (See Pl. VIII, *A*, p. 86.)

At Iliamna Bay the mountains extend eastward to the waters of Cook Inlet. Both north and south of this point a belt of foothills and lowlands, from 2 to 10 miles in width, reaches from the edge of the high mountains to the shore of the inlet. Much of the coast is deeply embayed, Tuxedni Bay, Iniskin Bay, and Iliamna Bay extending into the high mountains, and the other bays having their heads in the foothill belt. Iliamna and Bruin[1] bays head at well-known low passes through the mountains, and Tuxedni Bay and the southwest arm of Kamishak Bay are reported to have passable routes from them

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[1] Locally known as Bear Bay.

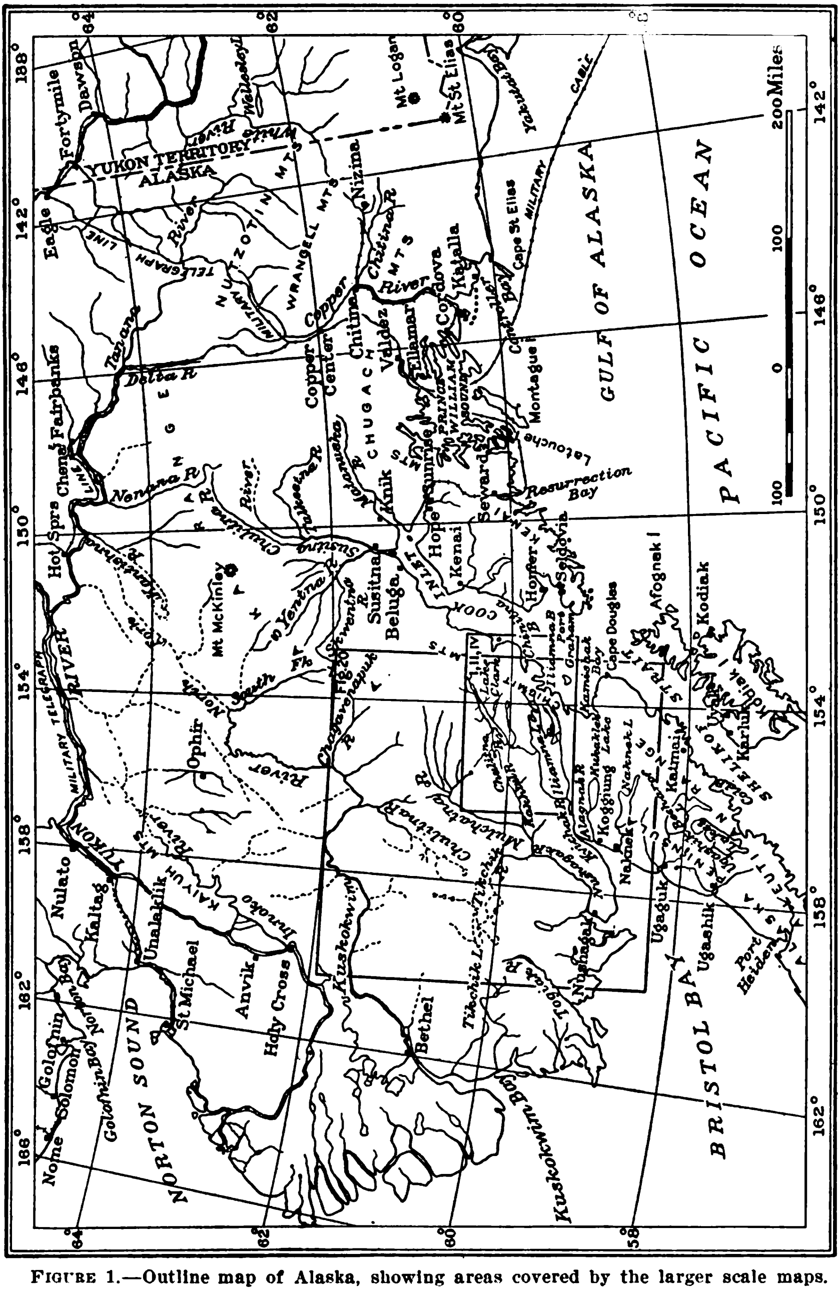


Figure 1.—Outline map of south-central Alaska, showing areas covered by the larger-scale maps.

Figure 1.—Outline map of Alaska, showing areas covered by the larger scale maps.

through the mountains. The topographic features of such parts of the region as have been surveyed are shown on Plate I (in pocket).

The western part of the region lies in the wide valleys of the lower ends of Iliamna and Clark lakes and consists of low gravel-covered flats with numerous isolated hills and groups of hills distributed irregularly through them. At the west end of Iliamna Lake the valley opens out into the wide coastal plain of Bering Sea. A broad low pass at the head of Chulitna River leads into the Mulchatna Valley, which is a region of flats and low rounded hills. The general position of the Mulchatna region is shown on figure 20 (p. 131).

LAKES.

Iliamna Lake lies in the south-central part of the region. It is about 80 miles long and in general is from 8 to 20 miles wide, being the largest body of fresh water in Alaska. It is about 50 feet above tide, and drains through Kvichak River into Bristol Bay. Reported soundings indicate a depth, at the east end, of many hundred feet. Lake Clark, in the northern part of the region, is about 52 miles long and from 1 to 4 miles wide. It is about 220 feet above tide or 170 feet above Iliamna Lake, to which it is tributary through Sixmile Lake and Newhalen River. The depth of Lake Clark "about 6 miles east of Cape Shishkin and about half a mile from the south shore of the lake" (probably not far from Tanalian Point) was determined by Schanz[1] to exceed 606 feet. Sixmile Lake is at practically the same elevation as Lake Clark, from which it is separated by a short strait. It flows out through Newhalen River into Iliamna Lake. Kontrashibuna Lake, tributary to Lake Clark from the east through Tanalian River, is 14 miles long and half a mile to a mile wide and lies about 560 feet above tide. Upper and Lower Tazimina lakes, which are about 650 feet above tide, drain through Tazimina River into Sixmile Lake. Many other smaller lakes lie on the various tributaries of Lake Clark. Meadow and Moose lakes lie about 600 feet above tide, on the headwaters of the river which enters Iliamna Lake at the head of Intricate Bay. Kakhonak Lake, about 260 feet above tide, and another unnamed lake above it, drain through Kakhonak River into Iliamna Lake at the head of Kakhonak Bay. Hundreds of smaller lakes are distributed over the whole western part of the region.

RIVERS.

The largest stream of this region is Kvichak River, which flows from Iliamna Lake into Bristol Bay. Its length from the outlet of the lake to Koggiung is about 62 miles. In the upper 17 miles of its course it has an average current of probably 6 miles an hour and is much broken up by islands and bars into narrow, shallow channels.

---

[1] Schanz, A. B., Frank Leslie's Ill. Mag., vol. 73, 1891, p. 224.

The greater part of its fall is in this part of its course. For the next 13 miles it is somewhat less swift, probably running 3 or 4 miles an hour, and is confined in a single deep channel. The lower 32 miles of its course is tidal, the water being of considerable depth even at low tide. The river is navigated by cannery steamers for about 22 miles above Koggiung, and by launches and Columbia River boats (when favored by strong west winds) for its entire length.

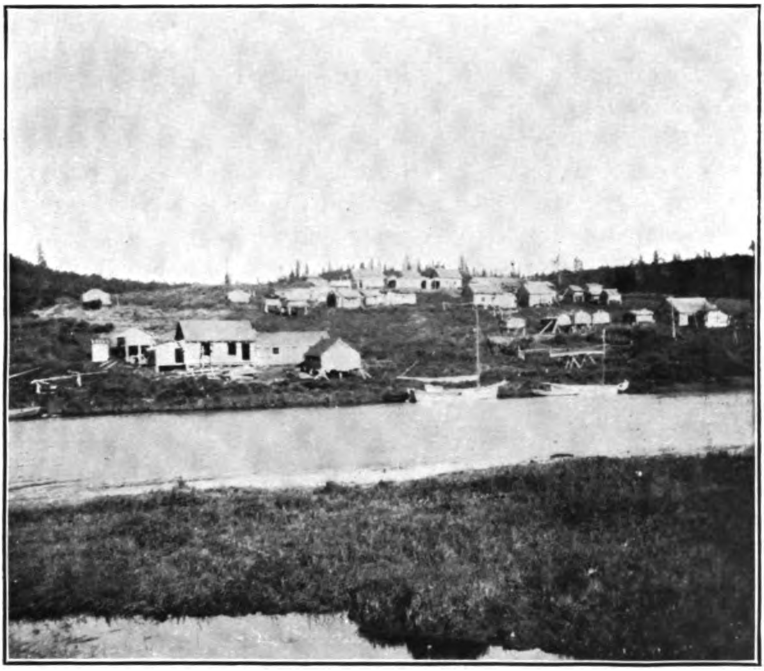
Newhalen River, the second stream of the area in size, is about half the volume of the Kvichak and about 23 miles in length. For the upper 11 miles of its course it can be navigated by canoes and poling boats. Rapids and reported falls make even canoe navigation impossible for the lower 12 miles. These rapids are avoided by a 5-mile portage.

The other large streams of the region are Pile, Iliamna, Kakhonak, Chekok, and other unnamed rivers tributary to Iliamna Lake; and Chulitna, Tlikakila, Chokotonk, and Tanalian rivers, and other streams tributary to Lake Clark. (See Pl. III.) Tazimina River, draining the lakes of the same name, enters Sixmile Lake just above its outlet. Large unnamed rivers enter Cook Inlet from the region here under discussion at the head of Tuxedni Bay and at the head of the southwesternmost arm of Kamishak Bay. The streams reaching Cook Inlet between these are all small.

Many of these streams may be used for water power whenever the development of the region creates a demand for it. One of the most promising water powers is on Tanalian River, which has a fall of 60 feet in a single drop at the outlet of Kontrashibuna Lake (Pl. III, *B*) and which descends about 340 feet in the 4½ miles between Kontrashibuna and Clark lakes. Tazimina River descends about 430 feet in about 8 miles from the lip of the hanging valley containing the Tazimina Lakes to Sixmile Lake, most of this fall being in a distance of 3 miles. Newhalen River descends nearly 170 feet in its lower rapids, which are distributed throughout a distance of about 6 miles. Meadow Lake lies about 550 feet above Iliamna Lake, and the stream draining it, which is about 20 miles long, may have available water power. Kakhonak Lake is about 210 feet above Iliamna Lake, and its water descends in a distance of about 5 miles. These streams are all large, and their flow is regulated by natural storage in lakes. Many of the smaller streams could also doubtless be used if local power should ever be needed.

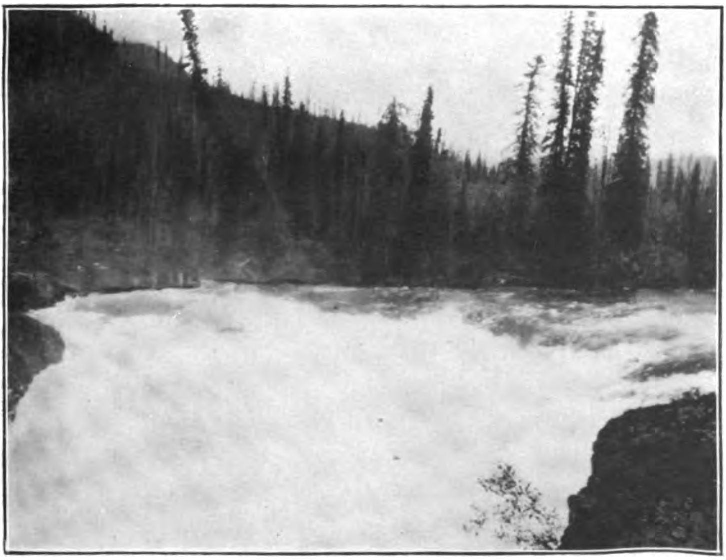
GLACIERS.

The existing glaciers of this region are neither numerous nor large. Only near Mounts Iliamna and Douglas, and outside of the area actually mapped, are there large unbroken areas above snow line



A. ILIAMNA VILLAGE AND RIVER.

Showing character of lowlands in valleys tributary to Iliamna Lake.



B. TANALIAN FALLS.

Showing water power and character of timber on Clark Lake

which are competent to form the gathering grounds for extensive glaciers.

There are 18 small glaciers in the headwaters of the drainage tributary to Kontrashibuna Lake, and four on the streams coming into Lake Clark near its head from the east. These glaciers lie at altitudes of 3,400 to 5,800 feet in the Kontrashibuna drainage, and 2,000 to 6,000 feet at the head of Lake Clark.

The snow fields around Mount Iliamna send out several valley glaciers of fair size. Three of these go to the south and are tributary to streams entering Chinitna Bay. They are known as East, Middle, and West glaciers. Another good-sized valley tongue goes out to the north and is tributary to the unnamed stream at the head of Tuxedni Bay. Several other glaciers of this type must flow west from these snow fields, but nothing is known of their position nor size. The abundance of glacial silt in the waters of Iliamna and Pile rivers and of all the larger streams east of Lake Clark is conclusive evidence of the existence of many glaciers in that region.

The high country around Mount Douglas and the neighboring peaks at the north end of the Aleutian Range is a notable feeding ground for glaciers. Seven or eight large glaciers are known to radiate from these snow fields, several of which reach almost to tidewater.

CLIMATE.

The climate of this region has some features of both the coast and the interior climates of Alaska. The coast of Alaska is characterized by heavy precipitation and by mild winters and rather cool summers. The interior of the Territory has far less precipitation, the conditions verging in places on semiaridity, and has very cold winters and rather warm summers.

This region has abundant precipitation, though not as much as the ocean coast. The early summer months are frequently favored with long intervals of clear weather. Similar conditions are said to exist also during part of the winter. It was noticed during the summer of 1909 that cloudiness and precipitation were much greater in the high mountains at the upper ends of Iliamna and Clark lakes and in the Aleutian Range than in the broad valleys of the lower ends of the lakes. In the summers of 1903 and 1904, cloudiness and rain were far less at the head of Kamishak Bay than on the mountainous parts of the coast both north and south of that point.

This region is also believed to have a colder winter and a warmer summer temperature than the open coast, in this respect also being intermediate between the coast and the interior.

The following fragmentary weather observations have been made within the area described:

Temperature (° F.) at Millet's camp (north shore of Iliamna Lake) from Dec. 1, 1907, to May 31, 1908.

[Records by O. B. Millet.]

	8 a. m.			7 p. m.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
December	38	−13	9.9	34	−10	11.3
January	34	−10	15.3	36	− 5	16.1
February	28	−30	−8.0	31	−26	−3.8
March	32	−20	11.1	34	−15	14.8
April	40	−13	26.3	40	3	29.3
May	49	30	40.7	65	29	41.6

Miscellaneous observations.

December 31, 1905.—Ice began to form on Iliamna Lake.[1]
January 12, 1906.—Ice 16 or 18 inches thick on Iliamna Lake.[1]
February 12, 1906.—Ice in Iliamna Bay.[1]
March 16, 1906.—Ground began to become bare.[1]
January 17, 1908.—Iliamna Lake froze.[2]
May 28, 1908.—Iliamna Lake opened.[2]
June 2, 1909.—Ice out of upper end of Iliamna Lake.[3]
June 20, 1909.—Ice all gone from Iliamna Lake.[3]
September 13, 1909.—Snow at 2,000 feet.[3]
September 17, 1909.—Snow at 1,200 feet.[3]
September 20, 1909.—Severe freeze.[3]
September 27, 1909.—Snow at Iliamna Bay.[3]

VEGETATION.

GENERAL FEATURES.

This region lies in the borderland between the densely forested coast of southeastern and south-central Alaska and the treeless coasts of the Alaska Peninsula and Bering Sea. Parts of it have the vegetation of the treeless tundras. Other parts have a vegetation rather closely akin to that of much of the lightly forested interior of Alaska and of much of northern Canada. Still other tracts are treeless because they are high and possess the universal features of the area above and near to snow line. The distribution of the forested and nonforested areas is shown on Plate IV.

FORESTS.

The forests extend throughout the lowland areas on the coast of Cook Inlet north of Iniskin Bay, in the valley of Lake Clark (Pl. III,

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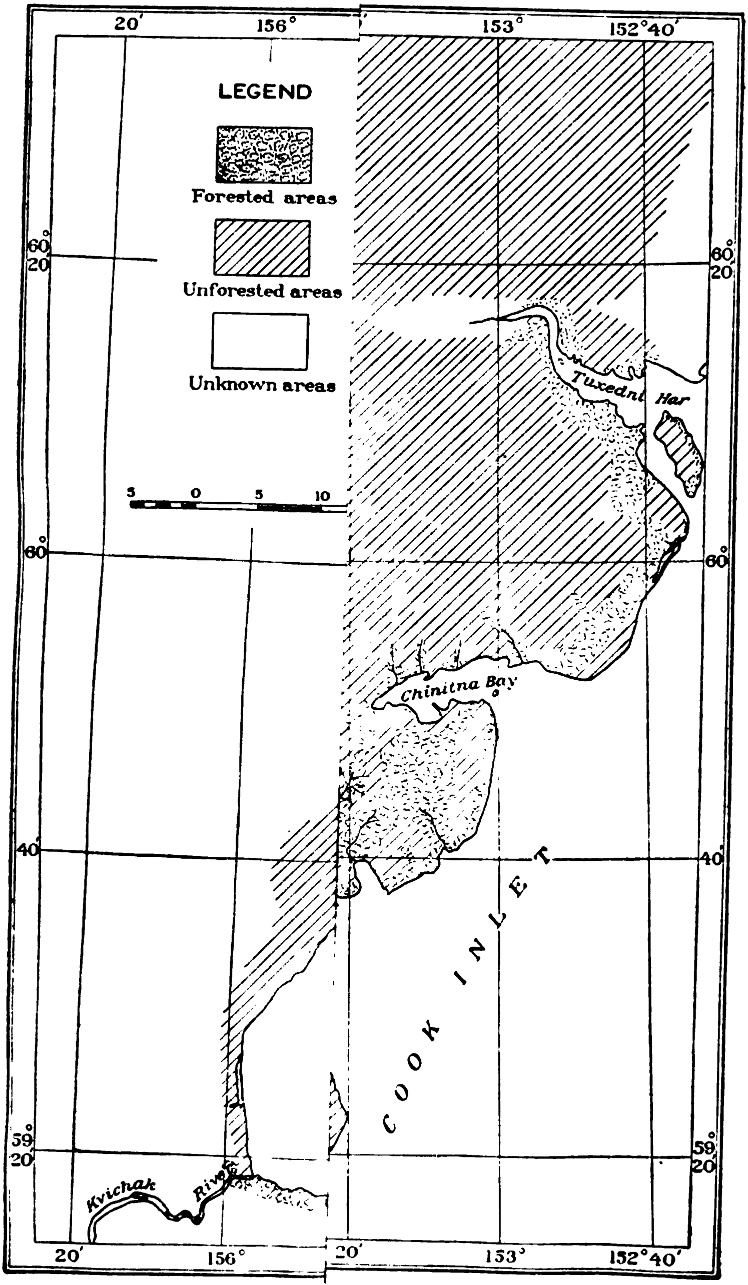
[1] Fifteenth annual report on the introduction of domestic reindeer into Alaska, 1906, pp. 168–172.
[2] Statement by O. B. Millet.
[3] Observations of U. S. Geological Survey.


LEGEND
Forested areas
Unforested areas
Unknown areas
5 0 5 10
20′
156°
153°
152°40′
60°20
60°
40′
59°20
Tuxedni Har
Chinitna Bay
COOK INLET
Kvichak River

B), and along the shores of Iliamna Lake east of longitude 155° W. The south shore of Iliamna Lake between longitude 155° W. and the outlet of the lake and most of the Kvichak Valley have only small scattered areas of forest. These forests consist chiefly of spruce with much birch intermingled with it or in separate groves. Birch is practically coextensive with the spruce throughout this region, except possibly on Cook Inlet. "Cottonwoods" also grow throughout the area of the spruce, but have a wider distribution, being present along many of the streams in the otherwise treeless areas.

The character of the vegetation at the mouth of Iliamna River has been described by Osgood[1] as follows:

> The timber in this vicinity is of the characteristic type found throughout the Hudsonian zone in northern Alaska. The white spruce (*Picea canadensis*) is the dominant tree, and with it are found its usual deciduous neighbors, the balsam poplar and the paper birch. Alders abound on the hillsides and willow thickets border the streams. Mosses, lichens, and small woody plants, chiefly Ericaceæ, cover the ground. A few small ponds near the river are bordered with grasses and sedges, and, where conditions favor, are filled with large yellow pond lilies (*Nymphœa*).

Concerning the timber on Lake Clark, Osgood[2] says:

> A good growth of timber surrounds the entire lake and runs up the mountain sides from 500 to about 1,500 feet. It is of much the same character as that at the head of Lake Iliamna. The black spruce (*Picea mariana*), which was not found about Lake Iliamna, however, is quite abundant on Lake Clark. This is particularly the case about the lower end of the lake, from the head of the Nogheling [Newhalen] River to Keejik, where there is more or less low, moist ground suited to the trees. The aspen (*Populus tremuloides*) is also found in a few places near the Nogheling and about Lake Clark. On the steep mountain sides south of the lake the white spruce is the principal tree, and in many places composes the entire forest. On the north side it is also abundant, but the deciduous poplars and birches are largely mixed with it. This difference in the timber of the two sides is doubtless due to slope exposure. Many of the small, low peninsulas projecting into the lake on the north side are almost entirely occupied by groves of poplars (*Populus balsamifera*), many individual trees slightly exceeding 12 inches in diameter. A beautiful open forest of birch and spruce is found in some localities, and much of the ground in some places produces tall grass (*Agrostis*) in great abundance. Devil's-club (*Echinopanax*) occurs in a few dark, sheltered places near the head of the lake, and perhaps reaches the northwestern limit of its range there. Willows and alders abound in their respective relative positions, while smaller shrubs and boreal plants are in characteristic profusion.

The spruce forests mentioned above contain good timber only locally. They are everywhere interspersed with open grassy meadows, bare ridges and hilltops, treeless swamps, and patches of alders and willows. (See Pl. III, *A*, p. 14.) Much of the spruce is, moreover, very small and is worthless save for firewood. None of the forest can really be classed as commercial timberland. The best of it would supply good lumber for little more than the slight present local needs. The supply of material suitable for mine timber is, however, probably adequate to any local demands which can now be foreseen.

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[1] Osgood, W. H., A biological reconnaissance of the base of the Alaska Peninsula: North Am. Fauna, No. 24, 1904, p. 11.

[2] Idem, pp. 13–14.

A rank growth of grass is present in all parts of the region, especially where the timber has been burned, and in the Cook Inlet lowlands. Abundant horse feed can be found throughout the greater part of the region, from about June 1 to October 1. Some hay is cut every year, especially near Iliamna village and the "Dutton prospects" and at the head of Cottonwood Bay. The areas of good grass are, however, not large and it is not probable that this could become a grazing country to more than a comparatively minor extent.

TREELESS AREAS.

The north shore of Iliamna Lake between Newhalen and Kvichak Rivers has no trees except "cottonwoods." The same condition holds on the west coast of Cook Inlet south of Iniskin Bay and over the greater part of the Alaska Peninsula. In the latter district spruce is known only on the shores of Iliamna Lake and on Kukak Bay.[1] It is definitely known to be absent on the southeast coast of the peninsula from Iliamna Bay to Cold Bay (except at Kukak Bay), along the route across the peninsula[2] from Naknek to Katmai, in the vicinity of Becharof Lake[3] and Ugashik Lakes,[4] and in the vicinity of Chignik Bay and Port Moller.[5]

The character of the vegetation in these nonforested areas at low altitudes is shown in the following description by Osgood[6] of the vegetation of the lower slopes around Iliamna Bay:

> They support no trees worthy of the name, but there are several groves of fair-sized balsam poplars (*Populus balsamifera*) in the narrow valley at the head of the bay and also on some low ground about a small indentation on the west side called Cottonwood Bay. On the mountain sides a few tiny spruces from 1 to 2 feet high proudly raise their heads above the matted mosses, lichens, and small shrubs. A few depauperate sprouts of the paper birch (*Betula papyrifera alaskana*) also occur. The characteristic shrubs are the alder (*Alnus viridis?*) and the dwarf birch (*Betula glandulosa rotundifolia*), which are found in great abundance.

Throughout this region the higher lands are bare of all vegetation except moss, grass, and small bushes. Timber line, the term being used to mean the upper limit in altitude of nonstunted spruce, and not the lateral limits of the forests where they abut on the low-altitude, nonforested areas, is in general at an altitude of 800 to 1,400 feet. Timber line was seen at its highest local altitudes near the heads of Clark, Kontrashibuna, and Upper Tazimina lakes, from which points it decreases to the south and west.

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[1] Fernow, B. C., Forests of Alaska: Harriman Alaska Expedition, vol. 2, 1902, p. 244.

[2] Spurr, J. E., and Post, W. S., Report of the Kuskokwim Expedition: Maps and description of routes of exploration in Alaska in 1898, p. 33.

[3] Osgood, W. H., A biologic reconnaissance of the base of the Alaska Peninsula: North American Fauna, No. 24, 1904, pp. 19–22.

[4] Observations of A. G. Maddren.

[5] According to several members of the Geological Survey.

[6] Osgood, W. H., op. cit., pp. 10–11.

Altitude of upper limit of spruce.

	Feet.
Head of Lake Clark	1,200–1,400
Kontrashibuna Lake	1,100–1,200
Head of Upper Tazimina Lake	1,200–1,400
North side, Lower Tazimina Lake	1,100
South side, Lower Tazimina Lake	900–1,000
West of lower end of Lake Clark	1,000
West of Newhalen River	800–1,000
Head of Pile Bay	1,000
Knutson Bay	800
East of Reindeer Station	800– 900

Large areas of "reindeer moss" are found throughout the greater part of the region, both in the open areas within the forested belt and in the nonforested areas. The low hills south of Iliamna Lake have an especial abundance of it. This has led to the establishment of the Government reindeer station at the head of Kakhonak Bay.

CAUSE OF LIMITS OF FORESTS.

In the lowlands of southwestern Alaska densely forested and absolutely unforested districts lie in close proximity, in areas which are not known or believed to differ appreciably in any characteristic determining the presence or absence of trees. Several explanations of this fact have been offered, and as some of these are geologic they are presented here.

Becker[1] believes that there may have been recent uplift of this part of the Alaska coast, and that the absence of trees may be due to the former presence of salt-water straits with heavy tidal currents connecting Bristol Bay with Cook Inlet by way of Iliamna and Clark lakes, and to the submergence of the western part of Kodiak Island.

This explanation was accepted as probable by Spurr,[2] who believes that the recent submergence is an established fact, and that the subsequent uplift has been so rapid that the timber has been unable to migrate westward at a rate equal to the retreat of the shore line.

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[1] Becker, G. F., Reconnaissance of the gold fields of southwestern Alaska, with some notes on the general geology: Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, 1898, p. 19.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 68.

Gannett[1] believes that the cause of the absence of timber is an open question. He holds that in neither rainfall, temperature, nor winds do the treeless areas differ from the forested coasts farther east.

On the other hand, Fernow[2] claims that the spruce has in very recent time migrated westward, and may still be migrating, although the movement is retarded by the prevalence of moist winds from the southeast and south from September to May. He subsequently[3] elaborated this explanation, holding that the Alaska Peninsula and Aleutian Islands show evidence of recent and volcanic origin, that a forest could come to them only from the northeast, and that for this to take place it is essential that the winds should be dry and should blow from the north and east when the spruce releases its seed, from September to May.

According to Osgood[4] it hardly seems possible that there is even an appreciable difference in temperature between the timbered region around Lake Clark and the treeless region around Becharof Lake. He believes that all the causes determining the nonexistence of coniferous trees can hardly be ascertained until more work is done, but that the prevalence of wind and storm regardless of temperature would restrict arborescent vegetation in almost any latitude, though in spite of these adverse circumstances the timber may be advancing.

The observations of the Geological Survey party in 1909 show that there is no essential difference between the forested and nonforested areas in rainfall, temperature, intensity of winds, or in rocks and soils. They also support the conclusions of Fernow and of Osgood that the forests are now advancing into the treeless areas. The evidence for this lies chiefly in the scarcity of old dead trees throughout most of the forest areas and their complete absence on the margins of the forests. The earlier geologic explanation by assumed recent elevation following a period of submergence must be discarded, for proof of these recent movements is not at hand.

SETTLEMENTS.

The largest settlement and the chief trading point for this entire region is Iliamna village (Pl. III, *A*, p. 14), situated on Iliamna River, 4 miles above its mouth and 12 miles from Iliamna Bay. This village has a population of about 15 whites and 40 natives. It has a United States commissioner and a Government school. Three stores are located here. A Government reindeer station has been located at the head of Kakhonak Bay since the spring of 1905. The other villages, which are inhabited permanently only by natives, include Kakhonak, on the south shore of Iliamna Lake 12 miles west of the head of Kakhonak Bay; Newhalen, near the mouth of Newhalen River; Nondalton, on the west shore of Sixmile Lake; and Kaskanak, on Kvichak River, about 10 miles below Iliamna Lake. Iliamna and Nondalton are Kenai villages, the others being Eskimo. The former villages of Chekok and Nikhkak are now abandoned. There are several cabins belonging to prospectors and traders at Iliamna and Cottonwood bays, but these are occupied only when a steamer is expected or when freight is being moved from the coast. Numerous isolated camps and cabins are scattered throughout the district. Most of these were built by prospectors, who have been at work in a small way since 1898 over the greater part of this region and in the adjacent Mulchatna country. The most active of these operations were from 1903 to 1906; they are described under the heading of "Mineral resources."

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[1] Gannett, Henry, General geography: Harriman Alaska Expedition, vol. 2, 1902, pp. 272–273.

[2] Fernow, B. E., Forests of Alaska: Harriman Alaska Expedition, vol. 2, 1902, pp. 244–246.

[3] Fernow, B. E., The forests of Alaska: Forestry and Irrigation, vol. 8, No. 2, 1902, p. 70.

[4] Osgood, W. H., A biologic reconnaissance of the base of the Alaska Peninsula: North Am. Fauna, No. 24, 1904, pp. 23–24.

Dutton post office, which was formerly situated at the head of Cottonwood Bay (the southern arm of Iliamna Bay), is now (1910) abandoned. The entire region is dependent for its summer mail on the accommodation of the postmasters east of Cook Inlet and of the mail clerks and other officers of the steamers calling at Iliamna Bay.[1] Winter mail is received by private delivery from points on the Cold Bay and Nushagak mail route.

The population of the local and neighboring villages according to census reports has been as follows:

Population of native villages.

	Tenth Census. 1880.	Eleventh Census, 1890.
"Chikak"	51	Not given.
Iliamna	49	76
Kakhonak	Not given.	28
Kaskanak	119	66
"Kichik"	91	Not given.
Koggiung	29	133
"Kivichakh"	Not given.	37
"Molchatna villages"	180	Not given.
"Nikhkak"	Not given.	42
"Noghelingamiut"	Not given.	16
	519	398

TRANSPORTATION ROUTES.

This region is accessible only by water, there being two well-traveled routes leading to it—one from the east by way of Iliamna Bay and the other from the west by way of Koggiung.

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[1] Iliamna post office was established in 1910.

The steamers from Seattle to Prince William Sound and Cook Inlet and also the local steamers from Valdez westward and from Seldovia and Port Graham to the upper Cook Inlet ports will land at Iliamna Bay whenever weather permits and sufficient business warrants it. Iliamna Bay is about a day's sail from Seward or 6 to 12 days from Seattle. There is usually about a boat a month from May to October, inclusive, and occasional boats during the winter.

A good horse trail leads from the head of Iliamna Bay to Iliamna village, a distance of about 12 miles. This trail crosses a 900-foot summit 3 miles west of Iliamna Bay. Another trail leads from the head of Cottonwood Bay to Iliamna village, about 20 miles, crossing three summits at elevations of 1,700, 1,500, and 1,975 feet, at 4, 5½, and 15 miles from Cottonwood Bay, descending to 1,400 and 600 feet between the summits. A good wagon road has been built for the first 2 miles and from the fifth to the fourteenth mile, or as far as the Dutton copper prospects. These trails can usually be used by horses from June 1 to November 1. Dogs are used during the rest of the year.

From Iliamna village all parts of Iliamna Lake and Kvichak River can be reached in boats, there being several large sailboats and a gasoline launch at the village. Horses can also be taken from Iliamna village throughout the greater part of the region, except in the high mountains. The shores of Lake Clark are impassable for horses east of longitude 154° W.

Bristol Bay is visited by cannery vessels about May 1, and by a passenger steamer from Valdez once a month in June, July, August, and September. Part of the supplies for the stores at Iliamna village are brought in by this route, which has the advantage of being all water and avoiding the portage from Iliamna Bay to the village.

Iliamna Lake can also be reached by a portage from the head of Kamishak Bay to the head of Kakhonak Bay. This route is said to be easy, the pass being low. It is, however, not much used except by natives, because of the difficulty of having supplies landed on this uncharted part of the coast.

Many of the supplies for Lake Clark and the Mulchatna country west of it are taken in from Iliamna village by dogs in the winter. Summer transportation to Lake Clark may be accomplished either with horses or by boats to a point on the shore of Iliamna Lake 4 miles east of Newhalen River, by a 5-mile portage from that point to Newhalen River above the lower rapids, and thence by boat up the Newhalen. Native packers are usually available at this portage.

The Mulchatna region can be reached from Lake Clark by boats up Chulitna River to a short portage at the head of Swan River, or up Chulitna and Koksetna rivers to points near the headwaters of other of the eastern tributaries of the Mulchatna. (See fig. 20, p. 131.) It can also be reached by taking horses over this same general route.

Railroad surveys for the proposed Alaska Shortline Railway were made from 1902 to 1908 along a route leading from the head of Iliamna Bay westward along the trail to Iliamna village, around the north shore of Iliamna Lake to Chekok Bay, northwestward to the lower end of Lake Clark, up the Chulitna Valley and across the Mulchatna Valley to the Kuskokwim and Yukon. An attempt was made in 1902 to carry mail and passengers over this route by the Trans-Alaska Co. Several miles of trail and a few cabins were built, but the venture was not a success.

ACCOUNT OF INVESTIGATIONS.

The field work on which this report is based was a combined topographic and geologic reconnaissance by a party of 12 men in charge of D. C. Witherspoon, topographer. The party landed and began work at Iliamna Bay, May 16, 1909. After crossing the mountains to Iliamna village two subparties were organized. One of these, in charge of Mr. Witherspoon, consisted of six men and was equipped with a pack train of eight horses. This party traversed the area north of Iliamna Lake and east of Lake Clark. F. J. Katz accompanied this party as geologist. The other party, in charge of G. C. Martin, geologist, likewise consisted of six men and was equipped with three Peterborough canoes. This party traversed the shore lines of Iliamna and Clark lakes, mapping as much of the topography and geology as could be reached from the shore, and made an exploratory trip down Kvichak River to Koggiung. C. E. Giffin accompanied this party as topographer and Theodore Chapin served as geologic field assistant. Field work for both parties ended at Iliamna Bay on September 28.

The results here given include the hitherto partly unpublished results of a geologic and topographic reconnaissance of the supposed oil fields between Iniskin and Chinitna bays made by G. C. Martin[1] in 1903, and of a similar reconnaissance by T. W. Stanton and G. C. Martin[2] in 1904, of the west coast of Cook Inlet from Tuxedni Bay to Cape Douglas and on the southern coast of the Alaska Peninsula.

Comparatively little was known of either the geology or the general features of this region prior to these investigations. The earlier explorations are, however, of interest and are briefly described below.

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[1] Petroleum fields of Alaska and the Bering River coal fields: Bull. U. S. Geol. Survey No. 225, 1904, pp. 365–382; The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits: Bull. U. S. Geol. Survey No. 250, 1905, pp. 37–49; Notes on the petroleum fields of Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 128–139.

[2] Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 291–410.

The first exploration of parts of this region of which records are available was by Pinart,[1] who, in 1872, made extensive explorations on the coast of the Alaska Peninsula and Bering Sea, ascending Kvichak River to Iliamna Lake. The results of these explorations are still largely unpublished.

Schanz and Clark, early in the winter of 1891, ascended Nushagak and Mulchatna rivers and explored the lower ends of Clark and Iliamna lakes. This expedition brought back important geographic information, but no geologic data. The accounts of this exploration, written by Schanz,[2] made known the existence of Lake Clark definitely to the general public for the first time. The presence of a large lake in this general position had, however, been vaguely known for a long time. In fact it had been represented on some of the early Russian charts, and it is now known that it was visited by McKay about 1881.

Later and more detailed information, including some geologic data, was gained in an exploration made for the Biological Survey by Osgood[3] and Maddren in 1902.

Brief geologic notes dealing chiefly with the outlying parts of this district have been published by Dall,[4] Spurr,[5] and Brooks.[6] Dall is the only one of these who was personally familiar with any part of the area described in this report, having studied the Jurassic rocks at Tuxedni Bay in 1896.

The United States Coast and Geodetic Survey made a detailed chart (No. 8665) of Iliamna Bay in 1907, and has been engaged in primary triangulation on Cook Inlet in the succeeding seasons.

The results of the investigation on which the present report is based have already been published[7] in abstract.

Although this is strictly a joint publication it nevertheless seems desirable to indicate the individual responsibility for the opinions here expressed by a brief statement as to the subdivision of the preparation of the manuscript.

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[1] Pinart, A. L., Voyage à la côte nord-ouest d'Amérique, d'Ounalashka à Kadiak (îles Aléoutiennes et péninsule d'Aliaska): Bull. Géographie, 6th ser., vol. 6, Paris, 1873, pp. 561–580, map.

[2] Schanz, A. B., Frank Leslie's Ill. Mag., vol. 73, 1891, pp. 138, 240; The fourth or Nushagak district: Report on population and resources of Alaska at the Eleventh Census, 1890, pp. 91–97.

[3] Osgood, W. H., A biologic reconnaissance along the base of the Alaska Peninsula: North Am. Fauna No. 24, 1904, 86 pp.; Lake Clark, a little known Alaskan lake: Nat. Geog. Mag., vol. 15, 1904, pp. 326–331.

[4] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 763–906.

[5] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898; Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 33–264; Lakes Iliamna and Clark: Maps and descriptions of routes of exploration in Alaska in 1898, with general information concerning the Territory, U. S. Geol. Survey, 1899, p. 129.

[6] Brooks, A. H., The geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906.

[7] Martin, G. C., and Katz, F. J., Outline of the geology and mineral resources of the Iliamna and Clark lakes region: Bull. U. S. Geol. Survey No. 442, 1910, pp. 179–200. Katz, F. J., Gold placers of the Mulchatna: Bull. U. S. Geol. Survey No. 442, 1910, pp. 201–202.

The introduction (pp. 11–25) was written by the senior author, as were also the introductory pages (pp. 25–30) of the section on geology. In the description of the Paleozoic and Paleozoic or early Mesozoic rocks (pp. 30–41) the division of responsibility was as follows: The senior author wrote the discussions entitled "Areal distribution" and "Age," and the junior author wrote those entitled "Lithologic character" and "Petrographic description." The description of the Mesozoic and Tertiary rocks (pp. 41–82) was prepared by the senior author, with the exception of the sections on lithologic character of the porphyries and tuffs (pp. 51–58) and petrographic description of the granitic rocks (pp. 74–76) and of the basaltic flows and tuffs (pp. 79–81), which are the work of the junior author. In the section on the Qaternary (pp. 82–94) the junior author prepared the discussion of conditions of deposition of the glacial deposits (pp. 83–88) and the description of the high terrace gravels (pp. 91–92), the remainder of this section being the work of the senior author. The sections on structure and on historical geology (pp. 94–113) were prepared by the senior author. The junior author wrote the entire section on mineral resources (pp. 113–132), except pages 126–130 on petroleum.

GEOLOGY.

GENERAL FEATURES OF THE REGION.

The region here described covers the southern end and parts of the eastern and western sides of the Chigmit Mountains, the northern end of the Aleutian Range, an intermediate region lying between them, and parts of the Cook Inlet and Bristol Bay regions on the east and west sides. It consequently includes parts of several geographic and geologic subprovinces, the general features of which will be briefly reviewed before passing to the detailed description of the special area here under discussion.

The geologic subprovinces included in part by this area are the Cook Inlet basin on the east, the Chigmit Mountains west of it, the Alaska Peninsula in the southern part, the Bering Sea coastal plain in the western, and the Iliamna basin in a central portion between the last three. These subprovinces are each characterized by distinctive physiographic, stratigraphic, and structural features, and their boundaries according to any of these criteria not only are fairly distinct but are approximately concordant. The geologic map (Pl. II, in pocket) consequently shows approximately the local geographic limits of the subprovinces.

GEOLOGIC SUBPROVINCES.

COOK INLET BASIN.

The Cook Inlet basin is topographically a lowland area bounded by more or less linear-fronted mountain masses on the east and west sides. The waters of Cook Inlet occupy about half of the total area of the basin. The larger land areas are at the north end and on the east side. The bounding mountain masses are the Talkeetna, Chugach, and Kenai mountains on the east side of the basin and the Alaska, Chigmit, and Aleutian mountains on the west side. The mountain fronts are deeply embayed by the Matanuska and Turnagain Arm valleys, between the Talkeetna and Chugach and between the Chugach and Kenai mountains, respectively, and by valleys north of Mount Redoubt and at the head of Kamishak Bay, which separate the Chigmit Mountains from the Alaska and Aleutian ranges.

The rocks of the valley floor consist chiefly of Tertiary and Quaternary deposits. The former are only locally more than slightly folded, and are only partly consolidated. The latter consist chiefly of glacial outwash deposited in what are now a series of terraces, and underlain, in at least part of the region, by till.

The rocks of the bounding mountains are mostly granitic and metamorphic. Those of the Kenai and Chugach mountains are slaty sediments. The Talkeetna Mountains are largely quartz diorite, with some schists and other rocks. The Alaska Range consists chiefly of slightly metamorphosed Jurassic rocks. The Chigmit Mountains are largely granitic, although metamorphic and volcanic rocks also are present, as will be described below (pp. 27–28). The Aleutian Range is essentially volcanic, but considerable areas of granite rocks and of Mesozoic and Tertiary sediments are known to be present.

Intermediate in geographic position as well as in geologic character between the valley floor described above and the bounding mountains are locally developed belts of foothills. One of these borders the Cook Inlet basin along the eastern front of the Chigmit Mountains. These hills differ geologically from the floor of the basin and also from the bounding mountains in that they consist of unaltered Mesozoic sediments and volcanic rocks. Similar rocks are also present in the lowlands between the Chigmit and Aleutian ranges and in the foothills of the Kenai Mountains on the south shore of Kachemak Bay.

Only the western edge of the Cook Inlet basin is included within the area described in this report. It comprises the foothills and lowlands east of the Chigmit Mountains. The local rocks are unmetamorphosed Mesozoic sedimentary and volcanic beds with one or two small remnants of a former fringe of Tertiary rocks east of them. The structure is dominantly simple, the Jurassic and Tertiary rocks being but gently flexed and having a general dip eastward toward the center of the basin, the Triassic rocks alone being complexly folded.

CHIGMIT MOUNTAINS.

The Chigmit Mountains are that part of the Pacific mountain system which fronts on the west coast of Cook Inlet from Redoubt Bay to Bruin Bay. The neighboring parts of the Pacific mountain system are the Alaska Range, which is north of the Chigmit Mountains, and the Aleutian Range, which is south of them. The axes of these three ranges are parallel, but are offset progressively southeastward, so that the axis of the Chigmit Mountains occupies a position southeastward and coastward from that of the Alaska Range and northwestward and inland from that of the Aleutian Range. The northeastward continuation of the Chigmit Mountain belt is probably to be found in the Talkeetna Mountains, east of the Cook Inlet basin, with which it possesses many geologic features in common.

The eastern boundary of the Chigmit Mountains lies parallel to the coast of Cook Inlet. The northern termination is somewhere in the unexplored country northeast of Redoubt Bay. The southern end is at the head of Bruin Bay. The western boundaries are rather indefinite. The hills west and north of Kakhonak River and of Kakhonak Lake should not be included, but the mountains west of Lake Clark above Chulitna River and west of a line from Chekok Bay to the mouth of Currant Creek may be included or not, according to the point of view. These hills merge imperceptibly with the main mountain mass, which, in the writer's opinion, should include the mountains north of Chulitna River and east of Lake Clark and east of a line from the outlet of Lake Clark to the mouth of Iliamna River and thence to the head of Bruin Bay.

These mountains are a rugged mass, which has been mapped only within the area described in this report, and whose topographic detail is consequently largely unknown. The general height of the summits ranges from 4,000 to 6,000 feet, as is shown on the topographic map, Plate I (in pocket), and in the characteristic view shown on Plate VIII, *A* (p. 86). Many summits in the northern part of the mountain mass exceed 7,000 feet in height, and the isolated volcanic peaks, Iliamna and Redoubt, on the eastern front of the mountains rise to approximately 10,000 feet.

The Chigmit Mountains consist geologically of the granitic, metamorphic, and volcanic rocks described in the following pages. Their geology is not known outside of the area here described. Within this region they contain detached areas of gneisses and schists, probably of early Paleozoic age, overlain by limestones, slates, and greenstones, all considerably altered and severely folded, and probably chiefly of Paleozoic age. Some less altered Triassic limestone also is present. Large areas of porphyries and tuffs, probably of Lower Jurassic age, are found on the eastern and western flanks of the mountains. All these rocks are cut by great masses of granite which were intruded in early Jurassic time. The granite appears to occupy by far the greater part of the area of the mountains.

These mountains were formerly occupied by an extensive system of glaciers of the alpine type, which have left behind them the usual erosion features at all but the higher altitudes, which seem to have overtopped the ice, and are consequently of the ragged nonglacial form. Glacial deposits are in general scanty, doubtless because this was a region of vigorous glacial erosion rather than of glacial deposition. The character of the land surface from which these mountains were produced is not known.

ALASKA PENINSULA.

The southern border of the region here described is the north end of the Alaska Peninsula, which extends southwestward from Kamishak Bay between the waters of Iliamna Lake, Bristol Bay, and Bering Sea on the north and those of Shelikof Strait and the Pacific on the south.

The Alaska Peninsula consists of two parts, a mountain axis on the south and a coastal plain on the north. The mountains are the Aleutian Range, which consists of volcanic rocks, cutting Mesozoic and Tertiary sediments, and of granitic intrusives. The Aleutian Mountains extend from Cape Douglas to the western end of the peninsula, being broken by many low passes, of which the lowest and broadest is probably the one at the head of Becharof Lake. These mountains are separated from the Chigmit Mountains by a broad, low belt of rolling country which extends from the head of Kamishak Bay to the head of Kakhonak Bay on Iliamna Lake. The coastal plain forms the western part of the peninsula throughout the greater part of its length. It is covered with Quaternary gravel, sand, and clay, lying in a series of terraces.

ILIAMNA BASIN.

The Iliamna Basin constitutes a physiographic and geologic subprovince, here described for the first time. Its area is that of the greater part of the drainage basin of Iliamna and Clark lakes, including the broader reentrants between the southern ends of the Chigmit Mountains on the north and the Aleutian Range on the south, but not the narrow fiord of Lake Clark above the mouth of Chulitna River nor the deep narrow upper ends of the valleys tributary to the east sides of Clark and Iliamna lakes, which belong to the Chigmit Mountains.

This subprovince possesses a physiographic unity characterized by the breadth of valleys and terracing of their sides, by the moderate height of the mountains, by their distribution as isolated individuals or groups, and by the rounded character of their tops and sides. These physiographic features accompany and were in large part caused by the geologic features described below, which likewise characterize this subprovince as a whole and distinguish it from the neighboring subprovinces.

The rocks of the Iliamna Basin consist chiefly of volcanic flows and tuffs, which are not metamorphosed nor closely folded, and are overlain at the lower altitudes by terrace gravels and by a small amount of glacial till. At two points within the area of the volcanic rocks are small patches of older rocks apparently protruding through the volcanic mantle. One of these is the limestone west of Chekok Bay, and the other is the greenstone near the head of Kakhonak Bay. The volcanic rocks include Mesozoic porphyries and tuffs and Tertiary basalts and tuffs. The former occur also on the western border of the Chigmit Mountains, as described above. The basaltic flows and tuffs are apparently restricted to this subprovince and give it some of its most striking geologic characteristics. Over large areas the basalts are horizontal or but gently tilted and are prominently exposed in the escarpments surrounding the mesas which they form. The greater part of the district has been scoured by the large ice sheets which formerly occupied the basin, and all the lower areas are mantled by the till and the terrace gravels left upon the retreat of the ice.

BERING SEA COASTAL PLAIN.

The Bering Sea coastal plain extends along the greater part of the shore line of Bering Sea, attaining its broadest development, except for the Yukon-Kuskokwim delta, on the shores of Bristol Bay, where it is from 20 to 50 miles in width. The part of it described in this report extends from the west shore of Iliamna Lake to the mouth of the Kvichak River. This is a terraced plain, at few points exceeding 200 feet in height, composed of stratified gravels, sands, and clays. The eastern end of the Kvichak Valley contains some till, which probably underlies part and may underlie all of the plain. Exposures of hard rock are not known in this district and are not believed to exist.

This subprovince merges eastward into the Iliamna Basin, the western part of which contains the same gravel-covered terraces, and overlaps southward upon the Alaska Peninsula.

STRATIGRAPHIC GEOLOGY.

GENERAL FEATURES.

The rocks of this region include a great variety of sedimentary, metamorphic, intrusive, and volcanic types. As stated above (p. 25), the several physiographic and geologic subprovinces are each in general characterized by distinctive rocks or groups of rocks, although some of the groups of rocks recognized below are common to several of the subprovinces. At no locality is there a geologic section showing anywhere near the complete stratigraphic sequence. The complex structure and the general absence of fossils throughout all but the eastern part of the region make correlation and the establishment of a complete geologic section rather difficult and subject to doubt. The first table following shows what is now believed to be the local geologic sequence in various parts of the region as well as the probable correlation between these local fragmentary columns. The second table shows also the probable relations of these rocks with those of the neighboring regions.

PALEOZOIC ROCKS.

GNEISSES AND QUARTZITIC SCHISTS.

Areal distribution.—The oldest rocks of this region are believed to be some highly metamorphosed sediments now appearing as gneisses, mica schists, and quartzites. These rocks occupy two districts, a southern one in the mountains between Iliamna and Pile bays, and a northern in the valley of Lake Clark from the valley of Kontrashibuna Lake northward to the mountains west of Tlikakila River. The areas occupied by these rocks are shown on the geologic map, Plate II (in pocket).

The southern district is probably divided into two detached areas by a large intrusive mass of granitic rocks. The rocks of the eastern area are exposed on the trail 2 miles west of the head of Iliamna Bay, and also on the Hicks and Dutton trails west of Cottonwood Bay. This area is bordered on the east in part by the slates described below (pp. 35–38), and in part, as west of the head of Iliamna Bay, by granite which also probably forms the western boundary of the area. The western area extends from near the head of Meadow Lake northward to the valley of Iliamna River. It is bounded on the west by Triassic (?) limestone and on the east by granite, possibly being connected through the area of the latter, in undetected belts, with the eastern area described above.

The northern or Lake Clark district of quartzite and mica schist also consists of two areas, which are separated by the waters of the lake. The southern area, which is on the east side of Lake Clark,

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lies in the mountain west of the lower half of Kontrashibuna Lake, being bounded on the east by crystalline limestone and calcareous schist and on the west and south by much younger volcanic rocks. The northern area is on the northwest side of Lake Clark, from 3 to 5 miles south of the mouth of Tlikakila River. This is believed to be continuous with the other area, separated only by the waters of the lake. This area apparently has crystalline limestone on each side of it, the probable relation being anticlinal structure (see p. 107) and limestone overlying the schist.

Lithologic character.—The gneisses and schists lying west of Cottonwood Bay include both coarse and fine grained types, between which are many intermediate phases. The coarse-grained rocks are light colored and are either decidedly gneissic or granitoid in texture. They are composed of quartz, feldspar, and biotite, and in places also hornblende. The fine-grained types include dark-colored hornblende-feldspar rocks approaching schists in texture and quartzitic schist which is among the predominant rocks along the Dutton trail. These rocks have a general northeast strike and steep northwest dip. They are probably overthrust or overfolded upon the slate and greenstone which lies east of them.

The rocks of the western area north of Meadow Lake include some biotite gneiss but a larger proportion of coarse to fine hornblende gneiss and some chloritic schist. The adjacent rocks are limestone on the west, which is believed to overlie the gneiss unconformably, and granite on the east, which is regarded as intrusive into it.

The rocks of these two areas constitute an assemblage made up of members of at least two more or less distinct types. These are the coarser-grained and more highly metamorphosed gneisses and the finer-grained and less metamorphosed schists and quartzites. These two groups are deserving of differentiation and possibly belong to widely separated geologic periods.

The metamorphic rocks of Lake Clark consist of quartzite, mica schist, calcareous schist, and crystalline limestone. These are believed to be separated into the older series of quartzite and mica schist here described, and a younger series of calcareous schists and limestones, described on pages 32–35.

These rocks include distinctly sheared quartzites and argillaceous quartzites composed largely of quartz with varying amounts of biotite and accessory magnetite and carbonaceous material. They resemble the less metamorphosed and presumably younger division recognized above in the district west of Iliamna Bay. The rocks exposed on the east shore of Lake Clark west of Currant Creek and on the opposite shore eastward from Portage Creek are quartzites, quartzitic schists, and mica schists, of undoubted sedimentary origin, in alternate succession of moderately thin beds. These are minutely plicated, the axial planes of the folds and the schistosity being vertical and striking about N. 40° E. (magnetic). Some basic dikes invading this formation have been folded with it. Later undeformed granitic intrusives into this formation were seen also on the northernmost of the two islands opposite the mouth of Currant Creek.

Age.—The only evidence now available as to the age of the gneisses and schists is their degree of metamorphism. They are much more altered than any of the other rocks of the region and, as they are apparently not connected with them by metamorphic gradation facies, it must be concluded that they are older. This determines their age as certainly pre-Triassic. As some of the less metamorphosed rocks of the region also are pre-Triassic, the gneisses and schists must belong well down in the Paleozoic or possibly in part below it.

The rocks of other Alaskan regions with which these may be compared include the schists of Willow Creek[1] on the edge of the lower Matanuska Valley, and the "Klutina series"[2] farther east. Both of these lie in the same general belt with the rocks here described, and neither is of determined age. Other areas of rocks of the same general lithology occur in many parts of Alaska.[3]

CRYSTALLINE LIMESTONE AND CALCAREOUS SCHIST.

Areal distribution.—The more highly metamorphosed and presumably older calcareous rocks of this region are found in two districts—the shores of Clark and Kontrashibuna lakes, and the mountains west of Iliamna Bay.

The calcareous rocks of Lake Clark outcrop as a continuous belt along the eastern margin of the quartzitic schists described above (pp. 30–31) from a point near the mouth of Currant Creek on the shore of Lake Clark, southward to a point near the head of Kasna Creek, about 2½ miles south of Kontrashibuna Lake, beyond which they were not followed. They also outcrop on both east and west sides of the schist on the west side of Lake Clark about 4 miles below the mouth of Tlikakila River. Calcareous schist was seen on an island in the middle of Lake Clark west of the mouth of Currant Creek, this outcrop being interpreted as part of a limestone belt along the west side of the quartzitic schists, the rest of this belt, except at the exposure 5 miles below Tlikakila River, lying in the lake or concealed by younger volcanic rocks.

The crystalline limestone west of Iliamna Bay occurs in two small areas surrounded by gneiss. One of these areas is about 2 miles west of the head of Iliamna Bay on the trail to the village, and the other is 3 miles from the head of Cottonwood Bay on the Dutton trail to the copper prospects.

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[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 10–11.

[2] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, p. 410.

[3] Brooks, A. H., The geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 208–218.

The limestone southwest of Iliamna village might also be described here, but there is considerable doubt whether it is to be correlated with these older crystalline limestones or with the less-altered Triassic limestone described later (pp. 41–47).

Lithologic character.—The limestone and calcareous schist on Lake Clark apparently overlie the mica schists and quartzites already described. They have an apparent thickness of many hundred feet, but the complexity of folding is such that the actual thickness can not be determined. They are predominantly calcareous throughout, and pure limestone beds contribute to a large proportion of the thickness. The separation from the presumably underlying quartzitic rocks is made wholly on the basis of calcareous and noncalcareous character, neither unconformity nor difference in degree of metamorphism having been detected.

On the east side of Lake Clark the western and presumably lower part of the calcareous rocks is made up of thin interlaminated bands of schistose material and of fine-grained crystalline limestone. Immediately east of this a presumably higher horizon consists of fine-grained, light-colored limestone, in places coarsely crystalline. The exposures of this limestone are cut off on the north by the alluvial lowlands of Currant Creek. On the headland just north of Currant Creek the cliffs are of calcareous schist composed largely of sericitic and serpentinous material and calcite with chlorite and quartz and containing veinlets of quartz and epidote. A secondary parallelism of the materials is well developed. The rock is without much question a sheared calcareous argillite. This rock lies in line with the belt of the calcareous rocks south of Currant Creek, and the two have approximately parallel strike and dip. It may be regarded as the equivalent of the western part of the calcareous outcrops seen south of Currant Creek, or it may be a third, and presumably the highest horizon of the limestones. These rocks at all localities observed on Lake Clark are thoroughly recrystallized as the result of regional metamorphism. The degree of metamorphism is moreover the same in each of the recognized horizons.

The crystalline limestone or marble of the two small areas west of Iliamna Bay is a coarse rock composed almost exclusively of large grains (one-eighth to one-fourth inch) of calcite. No trace of bedding or of the original unaltered calcareous material remains. Noncalcareous constituents are practically lacking except for quartz veins.

These masses of marble may possibly be lenses in the surrounding gneiss, but they are more probably small detached areas of an unrecognized larger mass, having undetermined structural and stratigraphic relationship to the gneiss.

Age.—These calcareous metamorphic rocks have yielded no fossils, so the only available evidence of their age must be derived from their stratigraphic relation to the rocks in contact with them or from correlation on the basis of lithology and sequence.

The rocks in contact with the limestone of Lake Clark are (1) the granitic rocks, (2) the porphyries and tuffs, (3) the mica schists and quartzites. The granite, which is presumably early Jurassic, is intrusive into the limestone, which was metamorphosed and folded prior to the intrusion. The porphyries and tuffs, which are probably Lower Jurassic, rest unconformably upon the limestone. The mica schists and quartzites, which belong at an indeterminate horizon in the Paleozoic, underlie the limestone without known unconformity. Their degree of metamorphism is approximately the same as that of the limestone. The local evidence thus merely shows that the calcareous rocks are certainly pre-Jurassic.

The coarse crystalline limestone of the two small areas west of Iliamna Bay is metamorphosed to the same extent as the surrounding gneisses. It is certainly older than any of the neighboring rocks except the gneiss. There is no definite proof of its relation to the latter, but it is certainly older than the activities by which the gneiss was metamorphosed.

The crystalline limestones of Lake Clark and of the hills west of Iliamna Bay may reasonably be grouped together in the same general position, as they are of the same lithologic character and are in both localities associated with schistose and gneissic rocks. Each appears from its relations to the neighboring rocks to be certainly pre-Jurassic and probably pre-Triassic. They are presumably to be correlated with each other, although there is no definite proof of their identity.

The question which next arises is whether these crystalline limestones can be correlated with any other rocks in this region. The other limestones, with which possible correlation must be considered, are the fossiliferous Triassic limestone of Iliamna Lake and Iliamna Bay, and a limestone of more or less dubious age outcropping southwest of Iliamna village (pp. 41–47).

The possibility of correlating the crystalline limestone of Lake Clark with the limestone of Iliamna Lake is suggested by the areal distribution of the outcrops. These two limestone belts are of about the same width and are approximately in line with each other, being separated only by an area of younger and presumably overlapping volcanic beds. This naturally encourages a search for evidence that they are identical, as does also the fact that at no point within this region has a section been found containing two obviously distinct limestones. There are, however, important differences between the limestones of these two belts. The limestone of Lake Clark is much more strongly metamorphosed, which suggests its greater age. Another difference lies in the intimate association of the limestone of Lake Clark with schists, whereas the limestone of Iliamna Lake is associated with only igneous rocks. This may, however, be due merely to the accidental distribution of volcanic rocks younger than the limestones, which have happened at Iliamna Lake to bury all the older rocks except a small area of limestone. It is, however, rather remarkable that the easily eroded limestone alone should happen to protrude through the volcanics at this point. It must consequently be concluded that the limestone of Lake Clark can not be correlated with the limestone of Iliamna Lake, but must be considered as older. The latter is Triassic (p. 46) so the former must belong somewhere in the Paleozoic. As the greenstones and slates described below are also older than the Triassic limestone, yet are less metamorphosed than these crystalline limestones, the latter must belong well down in the Paleozoic. The Devonian limestones, which are present in considerable thickness in many parts of Alaska,[1] are perhaps their most probable equivalents.

PALEOZOIC OR EARLY MESOZOIC ROCKS.

SLATE AND CHERT.

Areal distribution.—Slates which are in some places associated with chert and other rocks were seen at several localities widely scattered throughout this region. The grouping of all these under one heading depends entirely upon the general lithologic similarity.

One area of these rocks lies along the face of the mountain west of Cottonwood Bay and up the valley at its head. The length of this belt and the character of its termination at either end is not known, but it does not extend as far north as the valley at the head of Iliamna Bay. The adjacent rocks are gneiss and schist on the west side and greenstone on the east.

Somewhat similar slates with associated cherts were seen at three localities between Kontrashibuna Lake and Iliamna Lake. One of these areas is south of Lower Tazimina Lake, about halfway between it and Iliamna Lake. A second is on the mountain 4 miles east of the lower end of Lake Clark. The third is on the south shore of Kontrashibuna Lake, not far above the outlet.

Another area of slates with much associated chert and altered igneous rocks and with several thin beds of limestone, were seen on either side of Lake Clark just above the mouth of Tlikakila River.

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[1] Brooks, A. H., The geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, 1906, pp. 218–221.

These rocks form the west shore of Lake Clark from 2 to 4 miles above the mouth of Tlikakila River, and the east shore for 3 miles above a point opposite the mouth of the same river. The longitudinal extent of this belt is not known.

Lithologic character.—The slaty rocks of Cottonwood Bay constitute a monotonous succession of many hundred and possibly several thousand feet of black slate without characteristic subdivisions (Pl. IX, *A*, p. 98), although a few thin beds of limestone and quartzite were seen, and possibly some schist or phyllite should be included along the western margin. Slaty cleavage is well developed, but no evidence of stronger metamorphism was seen. These rocks are considered to overlie unconformably the gneisses and schists west of them, although in the actual contact the slates are apparently below. This relation is considered as due to overturned folding or faulting. (See pp. 102–103.) The rocks east of the slates are the greenstones described below, which apparently underlie the slates, although here, too, it is believed that the succession is inverted and that the greenstone belongs above the slate.

Some schistose rocks apparently interbedded with these slates, though of rather dubious relations to them, were seen on the trail about 2 miles west of Cottonwood Bay, where there are some thoroughly metamorphosed rocks with well-developed "flow cleavage." They are made up principally of quartz and biotite of very fine grain and with strong dimensional parallelism. In this are scattered dark mica plates from 4 to 5 millimeters to 3 centimeters in longer diameter. Most of these are thin and lie in the plane of the rock cleavage, but a few are more nearly equidimensional, some being oblique to the cleavage. These mica plates appear to be aggregates of crystallographically nearly parallel flakes, lying in the plane of the rock cleavage. Quartz and albite are present also as small "augen." Zoisite, chlorite, and magnetite were seen in small amounts. In one specimen there are abundant small crystals of pyrite. The albite augen are generally single large grains with no dimensional orientation with respect to the rock cleavage. The minute mica flakes immediately around them are to some extent wrapped about them; that is, they are parallel with the periphery of the albite grains. The quartz augen are aggregates of interlocking grains, in some cases larger grains in the central portion and finer grains in the thin edge of the "eye," which is drawn out parallel to the rock cleavage.

As to the original character of these schists the evidence is as follows: The rock whose thickness is unknown, being something like a hundred or a few hundred feet, is overlain and perhaps underlain by slates. It may be sedimentary like them or it may be a flow or a sill. The microscopic textural evidence is that there were, in the original rock, grains of quartz and albite and grains of femic material out of which the large aggregates of mica plates were developed. These conditions would be fulfilled either by a porphyritic rock or by a conglomeratic sandstone containing some pebbles of basic material. The evidence of the mineral composition is in favor of either, though the abundant mica might be taken to indicate a somewhat higher femic content than sandstones generally have.

At each of the three areas of slaty rocks between Kontrashibuna and Iliamna lakes the rocks consist of very fine-grained black slate, argillites, or graywackes, and banded, white, gray, and dark-colored cherts, or very fine-grained quartzitic rocks. The cleavage in the slates is only imperfectly developed. These rocks are all minutely crumpled and no evidence could be obtained as to their thickness and age. The adjacent rocks are all volcanics, which from their slight degree of alteration are evidently much younger and which are believed to overlie the slates unconformably, burying them except in the areas noted above and probably in other small undetected areas.

The rocks on the west side of Lake Clark from 2 to 4 miles above the mouth of Tlikakila River consist predominantly of chert and slate, with some associated beds which suggest altered volcanic rocks, and with at least one observed bed of limestone about a foot thick. The slate has fairly well developed cleavage; the limestone, although of very fine grain, is somewhat recrystallized; and the chert is apparently unaltered. These rocks differ from the Cottonwood Bay slates in being less altered and in the presence of associated cherts and igneous rocks.

Age.—The evidence as to the age of the slates and cherts is very unsatisfactory. No fossils have been found in them, or in any rocks of neighboring provinces with which they could be correlated on the basis of similar lithology and stratigraphic sequence. The stratigraphic relations to the areally associated rocks is not of much aid, as most of these do not have their own age relations well established. It is, moreover, more or less doubtful whether all the rocks of the widely separated areas, here grouped under one heading, really belong together. The correlation of these local rocks with each other depends chiefly upon general lithologic similarity, the rocks of each area differing from the others in considerable detail.

The slates of Cottonwood Bay are clearly younger than the more metamorphosed gneisses and schists west of them, and older than the greenstone on the east. Their age relative to that of the limestones of this and of the other local districts is less clear. They are somewhat more altered than the limestone on Iliamna Bay and on Iliamna Lake, probably not much more altered than the limestone north of Meadow Lake, but decidedly less altered than that of Lake Clark.

The slates and chert of the district between Kontrashibuna and Iliamna lakes are more metamorphosed and distinctly older than the volcanic rocks with which they are areally associated. The latter are believed to be of early Jurassic age, although the evidence is not positive.

At the head of Lake Clark the adjacent rock masses are chiefly granitic. A granite mass, which is intrusive into the slate, lies east of them. West of them, on the east side of Lake Clark, is also granite upon which the slates are overthrust. On the opposite side of the lake and west of the slates this fault was not seen, but a granitic arkose of undetermined age lies against the slates. This granite is supposed to be part of, and of the same age as, the granite on the coast of Cook Inlet, which was probably intruded in the Lower Jurassic.

It may consequently be concluded that the slates are all certainly pre-Jurassic, and that at least those on Cottonwood Bay are older than the greenstone and hence Paleozoic. They are comparable in lithologic character and in their general relationships with the slates of the Sunrise "series"[1] of the Kenai Peninsula, the Valdez and Orca groups[2] of Prince William Sound, and the similar slaty rocks of doubtful age occurring throughout much of the Pacific coastal region of Alaska.

GREENSTONES.

Areal distribution.—Altered volcanic rocks here grouped under the name of "greenstone" occur at several places within this region. Considerable diversity of character exists among them, but they possess in common the following features: The presence of original basic igneous material, such a degree of alteration that the original character of that material in general can not be determined, original banding or secondary schistosity or both, and superficial similarity in color, texture, and general physical appearance.

A belt of these rocks extends across the heads of Iliamna and Cottonwood bays and northeastward and southwestward for unknown distances. The adjacent rock west of the greenstone at the head of Cottonwood Bay is the slate described above (pp. 35–36). Granite lies west of the greenstone at the head of Iliamna Bay, and also lies east of the greenstone belt throughout its known length.

Another large area of greenstone occupies the mountain southwest of Iliamna village between the lower end of the Iliamna Valley and Meadow Lake, extending westward to the shore of Pile Bay. It lies immediately west of a belt of limestone, the greenstone evidently being younger than the limestone, though it is not known whether the contact represents unconformity or intrusion (p. 44). Granite is intrusive into the greenstone on the shore of Pile Bay.

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[1] Moffit, F. H., Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 17–19.

[2] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910, pp. 22–33.

A small area of schistose amphibolite of indeterminate origin lies along the contact between granite and rhyolite near the mouth of Pile Bay.

Somewhat similar green schist (probably chloritic schist) occurs on the south shore of Kakhonak Bay near its head. The neighboring rocks are much younger altered volcanics, which are believed to be unconformable above it and here locally cut through by erosion.

Schistose greenstone also was seen on the west shore of Lake Clark opposite the mouth of Currant Creek. The extent of this area and its relations to neighboring rocks were not determined.

It is possible that the rock on the east shore of Lake Clark from 4 to 6 miles above the mouth of Currant Creek and on the west side of the Tlikakila Valley should also be grouped with this greenstone, but it may be only a facies of the Lower Jurassic porphyries and of tuffs, locally intensely altered by intrusion of the large neighboring granitic masses.

Petrographic description.—The greenstone on Iliamna Bay consists for the most part of dark-green aphanitic rocks here and there marked by whitish and epidote-green bands, and generally slightly schistose. In some places, as at the head of Iliamna Bay, the rocks show considerable schistosity, possibly due to local shearing, while at near-by localities they are rather massive but mottled with roundish bright-green spots from 1 inch to about a foot in diameter. Under the microscope one of the banded forms is seen to be made up largely of epidote, zoisite, and quartz with less important amounts of amphibole and feldspar. Variations in size of grain and in relative amounts of constituents produce the noticeable banding. Secondary (flow cleavage) structure cuts the banding, which is presumably primary, at a small angle. From the structure and composition it is assumed that the rock is a metamorphosed volcanic, perhaps a tuff.

The rocks of the area southwest of Iliamna village are for the most part thoroughly recrystallized quartz amphibolites or quartz-epidote amphibolites, their composition indicating that they have been derived from rocks related to diorite or diabase. One less thoroughly recrystallized rock from within this greenstone area, at a point about 7 miles southwest of Iliamna village (9M52), is very probably a partly altered pyroxenite. In it augite is seen altering the fibrous amphibole, beside which there is in the section some epidote, sericitic material, calcite, and limonite. The beds exposed on the shore of Pile Bay from 2 to 4 miles below the mouth of Iliamna River are in part tuffaceous. The rocks of this area as a whole are in general not very schistose.

The greenstones seen near the mouth of Pile Bay, near the head of Kakhonak Bay, and on the west shore of Lake Clark opposite Currant Creek, are much more altered than any of those described above, being completely recrystallized and possessing a thoroughly developed schistosity. They are probably to be classed as amphibolites and chloritic schists. No evidence of their origin was obtainable. They may be locally intensely metamorphosed representatives of the greenstones of the other areas or may belong among older series of rocks.

Age.—The greenstone on Cottonwood Bay is in contact with the slates described above (pp. 35–37). Although the slates rest upon the greenstone the former are considered older, as they are more metamorphosed, and the local attitude of the rocks is explained as being due to a fault or an overturned fold.

The contacts of greenstone and granite were seen at many places on Iliamna, Cottonwood, and Pile bays. At all of these places it is clearly evident that the contact is one of intrusion, the granite being younger. The granite is shown below (p. 76) to be of probable Lower Jurassic age. The greenstones must consequently be Triassic or older.

The Upper Triassic Kamishak chert at Ursus Cove contains much associated igneous material (Pl. V, *B*), some of which closely resembles the greenstone on Cottonwood Bay. This material is most abundant in the lower part of the Ursus Cove section (p. 47), the relations suggesting that the Kamishak chert grades downward into the greenstone and that the latter possibly belongs within the Triassic. It should be noted that the Upper Triassic cherts in the vicinity of Seldovia are also associated with volcanic material,[1] chiefly diabase. No evidence was obtainable as to whether these rocks were erupted contemporaneously with the deposition of the cherts or were intruded later. They were, however, deformed with the cherts, and are consequently pre-Jurassic. The similarity of conditions at Seldovia and at Ursus Cove is striking and suggestive.

The rocks of other neighboring regions with which these should be compared include the greenstone in the lower part of the Orca group[2] of Prince William Sound, and the Nikolai greenstone[3] of the Chitina Valley. The latter underlies the Chitistone limestone,

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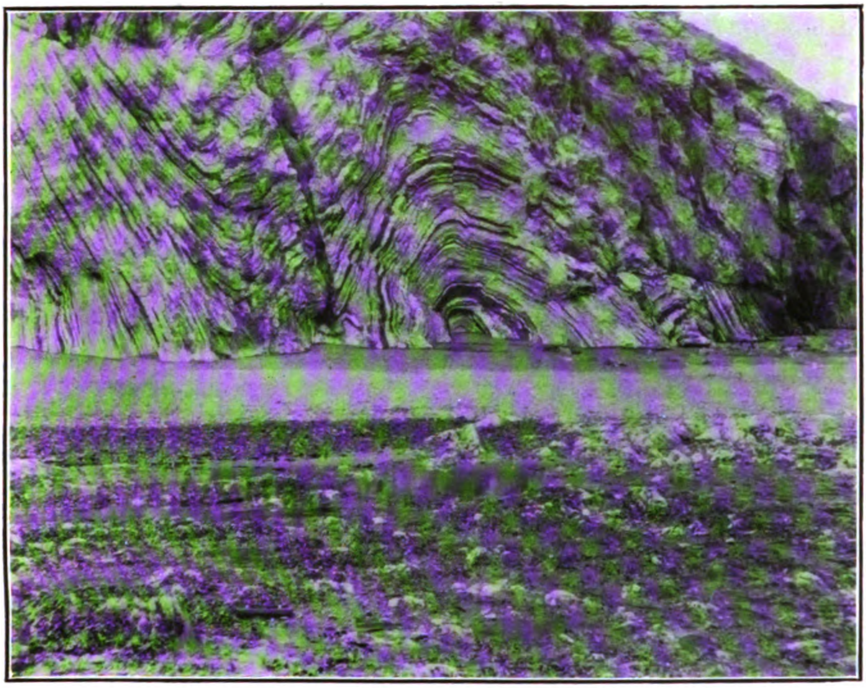
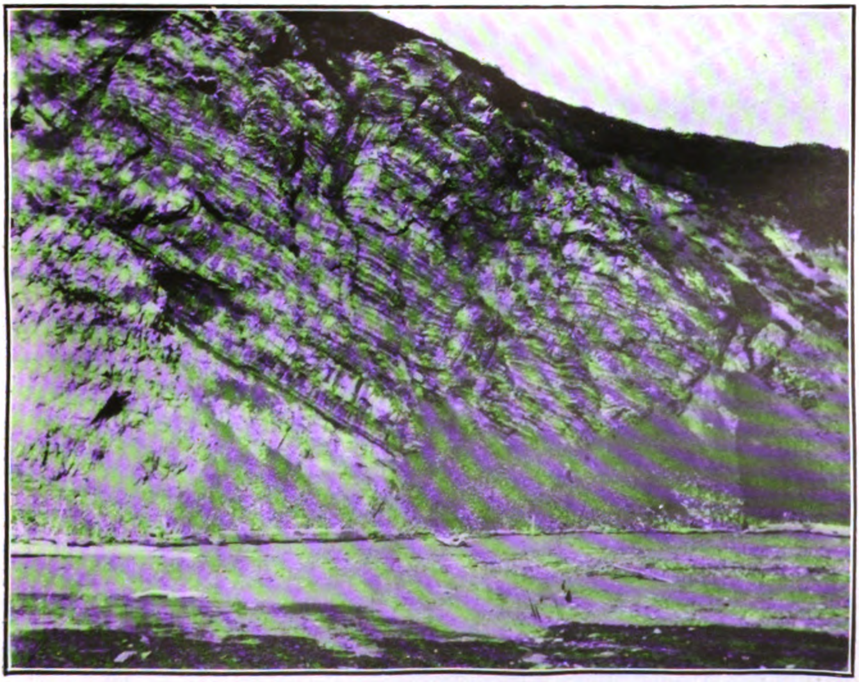
[1] Moffit, F. H., Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, p. 23.

[2] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: Bull. U. S. Geol. Survey No. 443, 1910, pp. 25–33.

[3] Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. U. S. Geol. Survey No. 374, 1909, pp. 23–25.



A. CLOSELY FOLDED KAMISHAK CHERT ON SOUTH SHORE OF BRUIN BAY.



B. KAMISHAK CHERT WITH INTRUSIVE SHEET OR FLOW OF BASIC IGNEOUS ROCK, ON NORTH SHORE OF URSUS COVE.

which is of upper Triassic age,[1] thus corresponding very closely in relation and presumably in position with the greenstone here described.

MESOZOIC ROCKS.

UPPER TRIASSIC ROCKS.

LIMESTONE.

Areal distribution.—Upper Triassic limestone is present on the north shore of Iliamna Lake at a point west of Chekok Bay and on the south shore of Iliamna Bay. The limestone southwest of Iliamna village is regarded as probably identical with this, and the already described crystalline limestones of Lake Clark and the mountains west of Iliamna Bay may possibly be its metamorphosed representatives. Limestone beds were also seen on the north shore of Ursus[2] Cove and on the south shore of Bruin[2] Bay in intimate association with the Kamishak chert. These beds may possibly be identical with the limestone here described, but as they have not been cartographically differentiated, and as they may be but thin members of the Kamishak chert, it seems best, temporarily at least, to include them in the Kamishak chert and to discuss them under that head in this report.

The limestone on the north shore of Iliamna Lake is exposed in the lake cliffs about 3 miles west of the mouth of Chekok River, or just east of Millet's copper prospects, which are located on the western edge of the limestone. The limestone belt is about two-thirds of a mile wide, and extends from the lake shore northward over the first ridge and down to the edge of the alluvium-floored valley beyond. No limestone was seen in the hills north of this valley, but possibly it may outcrop at points which were not visited, or more probably it may be buried beneath the volcanic rocks which were seen in these hills.

The limestone on Iliamna Bay occupies the cliffs on the south shore of the bay from a point due west of White Gull Island to a point almost south of it. The outcrop along the shore is somewhat over a mile wide, interrupted locally by several masses of igneous rock. The area of the limestone south of the bay is not known, but an outcrop of limestone was seen on the north shore of Ursus Cove, which may possibly be the same limestone as that on Iliamna Bay, but it is not believed to be areally continuous with it.

The limestone of the district southwest of Iliamna village occurs in a belt about 1,000 feet wide and is known to extend from a point 2 miles south of Iliamna village, on the edge of the flats of Iliamna Valley, to a point 9 miles southwest of the village, near the north end of Meadow Lake. It may possibly extend northward through the valley of Iliamna River and southward through the valley of the river draining Meadow Lake. In this case the northern termination of the belt may be an indefinite distance within the unexplored mountains, and the southern termination beneath the Tertiary lavas and tuffs east of Kakhonak Bay.

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[1] Moffit, F. H., and Capps, S. R., The geology and mineral resources of the Nizina district, Alaska: Bull. U. S. Geol. Survey No. 448, 1911, pp. 23–25.

[2] Ursus Cove and Bruin Bay are names adopted by the United States Geographic Board. These features are known locally and in earlier geologic publications as Bear Cove and Bear Bay.

Lithologic character and stratigraphic relationships.—The limestone on the north shore of Iliamna Lake is a fine-grained blue rock with a considerable amount of bituminous matter, which is revealed by a strong odor when the limestone is broken. It has been much shattered and crushed, the fractures healed by the deposition of fine-grained white calcite and some quartz. Otherwise it has not been much altered, no coarse crystallization of the noncrushed fragments having been observed except along the Millet copper lode, and there being apparently no development of secondary silicates. A part of the formation near Millet's cabin is rather siliceous.

The exposures in the cliffs on the shore of the lake (locality 1, p. 44) have yielded abundant but poorly preserved fossils, chiefly corals and mollusks. The corals are abundant, and the bed from which the specimens were collected is probably a reef, although the field observations, because of the complexity of the structure, are rather obscure on this point. It should be noted, however, that the identified species are true reef builders[1] and that reefs abound at this horizon in the Alps, in California, and in all the regions of lower latitude where this fauna is known. The occurrence here described is, however, the farthest north that Triassic corals have been found, and suggests a hitherto unknown extension of the distribution of Triassic coral reefs.

The stratigraphic relations to the neighboring rocks are obscure and offer so little aid in determining the position of the limestone that were it not for the presence of characteristic fossils no very definite determination of age could be made. The adjacent rocks on the south side of the limestone are tuffs which have at their base, resting discordantly across the beveled edges of the fossiliferous limestone, a bed of volcanic breccia consisting of angular fragments of limestone in a matrix of volcanic glass. This is regarded (p. 79) as the local base of a series of volcanic beds of Tertiary age. The rocks in contact with the limestone on the east and west sides are basic igneous masses, which are tentatively correlated on lithologic evidence (p. 58) with other volcanic rocks, which are believed to be Lower Jurassic. No local evidence of their relationship to the limestone was obtained. The exposures of limestone are cut off on the north by a gravel-covered flat. It may readily be seen that the only positive conclusions that can be drawn from the relationships at this locality are that the limestone is pre-Tertiary and that a profound unconformity separates it from the Tertiary beds.

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[1] The writers are indebted to Prof. James Perrin Smith for these facts.

The limestone on the south shore of Iliamna Bay is a large mass complexly folded so that no idea of its thickness may be obtained, and contains within its area intruded or structurally included masses of igneous rock. The limestone is white and blue, fine-grained, much shattered, the fractures healed with calcite, and very slightly altered save by this crushing and healing. In all this it resembles the limestone on Iliamna Lake, as it does also in the presence of a fauna which includes corals.

The associated rocks are amygdaloidal basaltic tuffs of indeterminate relationship on the west side and younger granitic intrusives on the east. The tuffs are probably Lower Jurassic (p. 58), but their structural relationships with the limestone have not been determined. The granitic rocks are believed to be late Lower Jurassic or Middle Jurassic (p. 76). They are intrusive into and hence younger than the limestone, which must consequently be pre-Jurassic.

The lithologic character and degree of metamorphism of the limestone at this locality is not very different from that of the limestone on Iliamna Lake. Fossils are present (locality 2, p. 44), but the fauna is scanty and poorly preserved and can not be definitely correlated with that from Iliamna Lake. Nevertheless the suggestion of identity of the limestones of these two localities, from the combined evidence of lithologic similarity, degree of alteration, and presence of approximately similar coral faunas, is very strong. It should be remembered that this locality is about 34 miles east of the locality of Iliamna Lake and across the granitic Chigmit Mountains.

The limestone southwest of Iliamna village is of the same general character as that on Iliamna Lake and on Iliamna Bay. It evidently was originally a rather pure and homogeneous rock. It is intricately folded and intensely crushed and shattered, but is not, however, greatly metamorphosed, coarse and thorough recrystallization being apparently largely confined to the lode zones. This rock is somewhat more altered than the limestone on the north shore of Iliamna Lake, but decidedly less so than that on Lake Clark. In its relation to the schist it resembles the latter, although there is here a strong suggestion of greater alteration of the schist than of the limestone and presumably of an important time break between their dates of deposition. The character of the folding is such that no estimate of thickness can be made.

The adjacent rocks are gneisses and schists on the east and altered basic igneous rocks (greenstone) on the west. Several masses of schist occur within the limestone, but whether they are interbedded or brought in by structural disturbances is not known. The latter is believed to be more probable, since the schists are apparently more metamorphosed than the limestone.

This limestone, which is about 13 miles distant from that on Iliamna Bay, has yielded no fossils and can be correlated with the limestone at the other localities of the region only on lithologic evidence. Its relation to the rocks in contact with it contributes a little to the evidence of its age. The gneisses and schists east of it are considerably more metamorphosed than the limestone and are believed to be unconformably below it and much older. The age of these rocks is, however, not known, so they give no proof of the age of the limestone. The fact that this limestone is less metamorphosed than the neighboring schist and gneiss, whereas the limestone of Lake Clark is metamorphosed to the same degree as the schist in contact with it, makes it necessary to conclude that if the limestone of Lake Clark and that southwest of Iliamna village are of the same age then the schists underlying them in the two districts are of different ages, or else the schist and gneiss in the latter district were metamorphosed prior to the deposition of the limestone and that in the former district subsequent to it. The rocks in contact with the limestone on its west side are altered basic igneous masses, originally diabase or diorite in composition and in part tuffaceous, but now altered to greenstone. These rocks are certainly older than the Lower or Middle Jurassic granite which is intrusive into them, and consequently are probably Triassic or older. (See p. 40.) The greenstone appears to be younger than the limestone, although the exact relations have not been positively established. The doubtful point is whether certain basic igneous rocks which are known to be intrusive into the limestone are an integral part of the main greenstone mass or are younger intrusions along the contact. Upon this point depends the determination of the age of the limestone. If the greenstone as a whole is younger than the limestone then the latter is pre-Triassic and probably belongs with the crystalline limestone described above (pp. 32–34) rather than with those under discussion here. If, however, the basic rocks which cut the limestone are not part of the main greenstone mass, then there is no local proof as to the relative ages of the limestone and greenstone, and they can be correlated, as the lithologic evidence seems to warrant, with the similar rocks on Iliamna Bay. This interpretation of the stratigraphic relationship is accordingly adopted, even though it can not be regarded as positively established.

Fauna.—Marine fossils have been collected from the following localities:

Locality 1.—North shore of Iliamna Lake, 3 miles west of mouth of Chekok River (near Millet's camp).

Locality 2.—South shore of Iliamna Bay, 1.1 miles S. 75° W. of west end of White Gull Island.

These collections were referred to Dr. George H. Girty, and on his determining them to be of Triassic age they were placed in the hands of Prof. James Perrin Smith, who is making an extensive study of the American Triassic faunas. The most striking feature of the present collections is that they consist largely of species of corals. Prof. Smith was already familiar with a closely related coral fauna in the Triassic of California and confined his report to the fossils of that zoologic group. Both reports are quoted below. Dr. Girty writes:

> The largest collection, and that furnishing the most varied fauna, is from locality 1. The dominant types of this fauna are the corals, to which I shall refer later. There are in addition an echinoid spine, a large number of fragmentary and ill-preserved pelecypods, a smaller number of gastropods, which are likewise and for the same reason undeterminable, and two species of brachiopods. There are evidently several types among the gastropods, and also among the pelecypods. One of the latter is marked by radiating ribs and has the general appearance of *Pecten*, *Lima*, *Pseudomonotis*, etc. There may be two species of this sort. One of the brachiopods, represented by several fragments, is probably a terebratuloid, but its generic affinities are doubtful. The other species is fairly abundant, and it is provisionally referred to *Bittnerula*. This is a rather small plicated shell with ribs also on the fold and sinus. The ventral valve is high and conical, with a high area marked by longitudinal striæ, which give the hinge a crenulated appearance. The shell substance is punctate. Fragments of the spiral arms can be seen on the inside. There are also short dental plates which converge and unite with the septum, as in *Cyrtina* and *Bittnerula*. All the *Cyrtinas* have a simple fold and sinus.
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> A comparison of the corals with those described by Frech[1] from the Alpine Trias reveals a striking resemblance between the Alaskan forms and those from the Alps. This is true of the astræid corals and is especially significant in the case of the spongiomorphine and tubularian forms. In view, therefore, of the fact that this fauna is completely unlike not only any Paleozoic faunas known from Alaska, but any known from North America, and that the corals are in the main of types unknown in the Paleozoic and show on the contrary marked affinities with Triassic corals, I am strongly of the opinion that the geologic age of this fauna is Triassic, in spite of the fact that it is unlike any of the known Triassic faunas of Alaska. If this opinion is correct, the occurrence in Alaska of this coral fauna of the Alpine Trias, and especially the development there of the singular group of spongiomorphine corals, is new and important.
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> Lot 2, from Iliamna Bay, contains a number of vague, imperfect shapes, of probably pelecypods, a few small corals, also indeterminable (cf. the form compared with *Thecosmilia*) and an imperfect *Halobia*-like type suggestive of some of the *Halobias* which have been brought down from the Triassic of Alaska elsewhere.

These collections will be described in detail in a future publication by Prof. James Perrin Smith, who has submitted the following preliminary report on them:

> The coral fauna is certainly Upper Triassic, of the lower Noric horizon. The species are closely allied to the Zlambach coral fauna of the Fischerwiese

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[1] Frech, Fritz, Die Korallenfauna der Trias: Palaeontographica, vol. 37, 1890, pp. 1–116, Pls. 1–21.

locality in the Alps, which is the best Noric coral fauna known. Some of the species are probably identical with forms I have collected in the Upper Triassic, Noric horizon, of Shasta County, Cal., and are represented by kindred forms in the Blue Mountains of Oregon.

These forms will have to be sectioned and studied with the microscope before positive identifications can be made, but the forms capable of more definite determination, and their probable affinities, are listed below:

Preliminary list of fossils from the limestone on Iliamna Lake.

Thecosmilia cf. fenestrata Reuss (also in Shasta County, Cal.).
Isastræa cf. profunda Reuss (also in Shasta County, Cal.).
Phyllocœnia cf. incrassata Frech.
Phyllocœnia cf. decussata Reuss.
Stylophyllopsis cf. mojsvari Frech (also in Shasta County).
Astrocœnia cf. waltheri Frech (probably same as in the Noric of Nevada).
Stylophyllopsis cf. zitteli Frech.
Heterastridium sp.? (probably the same as in Oregon).
Spongiomorpha sp.? (probably the same as in Oregon).

Age and correlation.—The paleontologic facts presented above clearly establish the age of the limestone on Iliamna Lake as Upper Triassic, and suggest the same age for the limestone on Iliamna Bay. The local stratigraphic relationships at the exposures of limestone on Iliamna Lake and Iliamna Bay prove only that the former is older than the Tertiary volcanic rocks and that the latter is older than the early Jurassic granite. The lithologic similarity of the limestones at these localities and the absence of anything which suggests discrepancy in age make it reasonable to assume that they are the same. The local stratigraphic evidence may also be considered as showing, with a fair degree of certainty, the identity of the limestone southwest of Iliamna village with that at the fossil localities, and as being perfectly in harmony with the assignment of the fossils to the Upper Triassic.

This limestone corresponds in its general character, as well as in its stratigraphic relationships, with the Chitistone limestone[1] of the Chitina Valley. It is similar in sequence, as is shown by the fact that the Chitistone limestone is overlain conformably by the McCarthy shale, which carries the same fauna as does the Kamishak chert, and is underlain by greenstone, as the limestone here under discussion is believed to be. The Chitistone limestone is now known to carry an Upper Triassic fauna, including *Pseudomonotis subcircularis* and *Halobia* cf. *superba.*[2] It should be noted that neither of these species has been recognized with certainty in the limestone of Iliamna Lake and of Iliamna Bay, but that they do occur (p. 48) in beds referred to the Kamishak chert. Part of these, including the limestone bed at Bruin Bay, from which Stanton collected *Halobia* cf. *superba*, should possibly be included (p. 50) in the limestone formation here under discussion.

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[1] Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. U. S. Geol. Survey No. 374, 1909, pp. 25–28.

[2] Moffit, F. H., and Capps, S. R., The geology and mineral resources of the Nizina district, Alaska: Bull. U. S. Geol. Survey No. 448, 1911, pp. 23–25.

KAMISHAK CHERT.

Areal distribution.—The Kamishak chert is typically exposed on the west shore of Kamishak Bay, especially in the vicinity of Bruin Bay. These rocks occupy practically all of the peninsula on the south side of Bruin Bay and also appear to form most of the southern shore of the bay west of the peninsula, as well as the eastern half of the north shore of the bay. These exposures are part of a northeast-southwest trending belt which occupies the coast of Kamishak Bay for 3 or 4 miles north of the entrance to Bruin Bay and probably also from the fourth to the seventh mile southwest of the entrance.

The same rocks were seen on Ursus Cove, where they occupy the greater part of the north shore, and extend thence northward in an apparently continuous belt to the south shore of Cottonwood Bay, near its head. At this last locality several hundred feet of chert is exposed in the cliffs just east of the low pass leading southward to Ursus Cove.

Lithologic character.—These rocks, where exposed on Bruin Bay, consist of thin-bedded chert, black calcareous shale, and impure limestone. The chert and limestone are generally black, green, or dark red when fresh, but weather to lighter shades. The whole series is complexly crumpled and faulted (see Pl. V, *A*, p. 40) and is cut by a multitude of small calcite veins. A large mass of quartz diorite, intrusive into these rocks at the end of the peninsula on the south shore of Bruin Bay, has locally transformed the limestone into white crystalline marble.

At Ursus Cove the predominant rock is the chert, which occurs in massive beds, interstratified with thinner beds of limestone, shale, and sandstone. In the lower part of the section at Ursus Cove there are large amounts of fine-grained, green igneous rock, intimately but obscurely associated with the chert. (See Pl. V, *B*, p. 40.) It is somewhat doubtful whether it is intrusive or interbedded. This rock is somewhat altered, especially in the formation of epidote, and resembles in a way the greenstone at the head of Cottonwood Bay. A bed of limestone exposed at the mouth of the creek which heads near Cottonwood Bay is of importance, as it has yielded a few fossils which are discussed below. (Lot 3, p. 48.) This limestone was regarded in the field as a thin bed interstratified with and a member of the Kamishak chert, because of the presence, practically in contact with the limestone, of chert beds which are essentially identical in lithologic character with those interbedded with the shales from which Stanton collected *Pseudomonotis subcircularis* in the same cliffs and only a short distance away, and because of essentially the same degree of alteration in the limestone and in the known Triassic beds. It was furthermore concluded in the field that this limestone was decidedly less metamorphosed than the limestone only 6 miles distant on Iliamna Bay, and was hence presumably younger and separated from it by a considerable time and structural break. This conclusion was supported by the fact that the cherts are found on Cottonwood Bay, only 2 miles from the limestone on Iliamna Bay, and are no more altered than on Ursus Cove. From these facts it seemed evident that the limestone at Ursus Cove was but a member of the Kamishak chert and that the limestone at Iliamna Bay was considerably older. Other possibilities must, however, be admitted. The structure at the Ursus Cove locality is complex and it is entirely possible, so far as the field observations are concerned, that the limestone is part of an older formation folded or faulted in with the Kamishak chert. If this is the case the limestone may well be the same as the Triassic limestone described above.

The exposures seen at Cottonwood Bay consist entirely of chert. These exposures, however, are not extensive, and probably only a small portion of the formation is represented.

The total thickness of the formation is not known, the beds being so disturbed that no accurate measurement could be made. At Ursus Cove the thickness probably exceeds 2,000 feet and may be much greater.

Fauna.—Fossils have been collected from the shales and limestones interbedded with the chert beds in this formation at Ursus Cove and at Bruin Bay. These, according to Stanton's determination, consist of *Pseudomonotis subcircularis* (Gabb) from Ursus Cove, and *Halobia* cf. *superba* Mojsisovics from Bruin Bay.

The limestone at Ursus Cove, described above (p. 47), has yielded a few fossils, which have been examined by Dr. George H. Girty, who says of them:

> They are much less extensive and diagnostic than the fossils from the Triassic limestone on Iliamna Lake (p. 45), but are connected with the latter by a massive astræid coral having similar characters with one of them. There are in addition a gastropod having the general shape of *Natica* or *Naticopis* and a pelecypod probably belonging to one of the subgenera of *Cardium*.

Age and correlation.—The *Pseudomonotis* and *Halobia* mentioned above are characteristic Upper Triassic species and clearly establish the Upper Triassic age of this formation.

Among the rocks of other Alaskan regions with which these should be compared are beds from Cold Bay on the Alaska Peninsula from which *Pseudomonotis subcircularis* was described by Fischer[1] as *Monotis salinaria* Bronn, and from which the same species has subsequently been collected by Stanton.[2] The presence of this species as well as the similarity of the rocks is sufficient to determine the equivalence of these beds with those at that locality.

The cherts and associated igneous rocks on the west shore of Kenai Peninsula[3] at Halibut Cove, Seldovia, and Port Graham, have previously been correlated[4] with these rocks on the basis of the lithologic similarity, and of the relation to Lower Jurassic beds which apparently overlie them unconformably. These rocks were reexamined in 1909 by Grant and Higgins.[5] Though they found no fossils in the rocks which they regarded as belonging indisputably to these cherts and tuffs, they collected *Halobia* cf. *superba* from cherts and limestones which they regarded as conformably beneath the previously recognized Lower Jurassic beds.

The McCarthy shale of the Chitina Valley, which consists of shales interbedded with thin limestones, is also characterized by the presence[6] of *Pseudomonotis subcircularis.* The stratigraphic relationship of the McCarthy shale to the conformably underlying Chitistone limestone is likewise similar to the apparent relationship between the Kamishak chert and its subjacent limestone.

A somewhat similar and possibly equivalent fauna, which, among other forms, includes *Pseudomonotis subcircularis* and *Halobia superba* (?) has been found by W. W. Atwood in limestones at Hamilton Bay, Kupreanof Island, in southeastern Alaska.[7]

The beds outside of Alaska with which these may be compared include the Swearinger slate, which is the uppermost Triassic formation of California and which is characterized by *Pseudomonotis subcircularis.* The relations of this formation to the other Triassic rocks of California, including the beds characterized by *Halobia superba,* has been discussed by Prof. James Perrin Smith.[8] It should be noted that these two fossils are regarded by Smith as characteristic, in California and elsewhere, of separate zones. The

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[1] Fischer, M. P., Sur quelques fossiles de l'Alaska: Compt. Rend. Acad. Sci., Paris, vol. 75, 1872, pp. 1784–1786. Also in Pinart's "Voyages à la côte nord-ouest de l'Amérique," pt. 1, Paris, 1875, pp. 33–36, Pl. A.

[2] Bull. Geol. Soc. America, vol. 16, 1905, pp. 394–396.

[3] Emerson, B. K., General geology: Harriman Alaska Expedition, vol. 4, 1904, pp. 26, 27. Moffit, F. H., Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 19–20, 23.

[4] Stanton, T. W., and Martin, G. C., Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, p. 393.

[5] Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, pp. 167–168.

[6] Moffit, F. H., and Capps, S. R., The geology and mineral resources of the Nizina district, Alaska: Bull. U. S. Geol. Survey No. 448, 1911, p. 30.

[7] Wright, F. E. and C. W., Bull. U. S. Geol. Survey No. 347, 1908, p. 57.

[8] The comparative stratigraphy of the marine Trias of Western America: Proc. California Acad. Sci., 3d ser., vol. 1, 1904, pp. 323–430.

Pseudomonotis he regards as characteristic of the highest California Triassic beds, being the equivalent of the Noric stage of the European geologists, and the *Halobia* as characteristic of beds lower down, and within the Hosselkus limestone, the European equivalent being the Karnic stage of the Upper Triassic. A suggestion of a somewhat similar range is found in Alaska, where the *Halobia* is found in the Chitistone limestone but not in the overlying McCarthy shale, in the limestone members (?) provisionally referred to the Kamishak chert but not in the typical and presumably higher beds of the formation, and in the beds of less certain horizon at Port Graham and Hamilton Bay. The *Pseudomonotis* is abundant, and is practically the only fossil in the typical beds of the Kamishak chert, in the presumably equivalent beds at Cold Bay, and in the McCarthy shale. It is reported, however, from the Chitistone limestone and from beds supposed to be below those which yielded *Halobia* at Hamilton Bay. This indicates, if the species and the horizons from which they have been collected have been correctly determined, that these species have in Alaska a somewhat different range from that which is supposed to be characteristic of them elsewhere. It is probably safer to assume the range to be the same and to look for specific differences or for errors in the field identification of horizons. The presence of *Halobia* in the limestone beds at Bruin Bay should perhaps be accepted as evidence that these beds are not members of the Kamishak chert but belong in or below the older Triassic limestone.

Beds carrying identical or closely related species of *Pseudomonotis* are known on Vancouver Island, the Queen Charlotte Islands, the mainland of British Columbia, and in Siberia and northern Europe.

LOWER JURASSIC (?) ROCKS.

PORPHYRIES AND TUFFS.

Areal distribution.—The rocks discussed under the above heading have been found in three districts: (1) On the shores of Iliamna Bay and elsewhere along the west coast of Cook Inlet; (2) north of Iliamna Lake from the valley of Chekok River northward through the valleys of Lower Tazimina and Kontrashibuna lakes to Lake Clark, possibly extending thence westward; and (3) at several detached areas on the south shore and on some of the islands of Iliamna Lake below Pile Bay. These rocks may or may not be of the same age. They are grouped together, in the absence of proof that they should be separated, for purposes of convenience, although it is admitted that further studies may show this grouping to be erroneous.

The rocks of the first district include those exposed on the south shore of Cottonwood and Iliamna bays and on the north shore of Iliamna Bay east of A. C. Point. These appear to be part of a more or less continuous belt extending parallel to the coast of Cook Inlet, other exposures of which are on the south shore of Ursus Cove, on the west and north shores of Iniskin Bay, near the head of Chinitna Bay, and on the western arm of Tuxedni Bay.

The second district includes an area east of the Newhalen Valley and of the southern half of Lake Clark and west of a line from the mouth of Chekok River to a point about two-thirds of the way up Kontrashibuna Lake. Most of the east shore of Lake Clark for a distance of about 8 miles above Tanalian Point also falls within it. It probably includes also an area between Currant Creek and Kontrashibuna Lake, and areas west of Lake Clark.

The third district includes four detached areas on the south shore of Iliamna Lake. The easternmost of these extends from near the mouth of Pile Bay, 15 miles below the head of the lake, to a point 27 miles below the head of the lake. Similar rocks occur near the head of Kakhonak Bay, and along the south shore of the lake from a point 4 miles west to 7 miles west of Kakhonak village and from 25 miles east to 19 miles east of the outlet of the lake. The islands south of Knutson Bay, as well as the north shore of Iliamna Lake between Knutson and Chekok bays, are also probably to be included in this district. These rocks show considerable difference in lithologic character from the volcanic rocks of Iliamna Bay and elsewhere in the first district on the west coast of Cook Inlet, which are described above. They appear, however, to correspond with them in general relation to the neighboring rocks, although little definite evidence of their age and relations is to be had. The same statements may be made concerning their relation to the rocks described from the second district.

Lithologic character in Cook Inlet district.—A thick series of volcanic beds, which include both flows and tuffs, overlies the Kamishak chert on the south shore of Cottonwood Bay with apparent conformity. Amygdaloidal basalts and volcanic agglomerates are among the more characteristic rocks of this series. Similar rocks were seen on the north shore of Iliamna Bay where they include fine-grained green and gray felsitic rocks and tuffs, in part cherty, invaded by large dikes of quartz-feldspar porphyry, and also on the south shore of Ursus Cove where quartz porphyry tuff, andesite, and andesitic and rhyolitic agglomerates are present. The belt also extends northward from Iliamna Bay, being exposed on the west and north shores of Iniskin Bay, where basalt, gabbro, and tuff are present; near the head of Chinitna Bay, where it includes olivine basalt and tuff, and on the upper arm of Tuxedni Bay, where quartz porphyry, augite andesite tuff, and quartz porphyry tuff were seen.

The basalts seen on Ursus Cove and Iliamna Bay are dark amygdaloidal porphyritic rocks containing small phenocrysts of basic plagioclase, augite, olivine (mostly serpentinized), and magnetite. The groundmass is a fine-grained holocrystalline aggregate of plagioclase, augite, and iron ores. Serpentine, calcite, opal, quartz and chalcedony, and limonite appear as secondary minerals and in the amygdules.

Augite andesites were found on the south shore of Tuxedni Bay and on Iliamna Bay. These are much-weathered rocks. Originally they had a groundmass of plagioclase and magnetite in which were phenocrysts of plagioclase and pyroxene, either diopside or augite. These latter minerals are now largely serpentinized or uralitized.

Andesites were seen on Chinitna Bay and Ursus Cove. The Chinitna Bay rock is a fine-grained, holocrystalline, slightly porphyritic rock composed largely of plagioclase, which is the only primary constituent now recognizable. Chlorite, serpentine, and iron oxides are present as secondary minerals.

The andesites of Ursus Cove are fine-grained porphyritic rocks considerably weathered. The groundmass contains plagioclase, a little quartz, and magnetite or ilmenite, together with secondary chlorite, calcite, and epidote. The phenocrysts are of plagioclase, about oligoclase or andesine in composition. so far as their weathered condition permits determination.

The quartz porphyries from Tuxedni Bay, Iliamna Bay, and Ursus Cove are greenish or dark porphyritic rocks with felsitic groundmass. The phenocrysts are corroded and embayed quartz and euhedral acidic plagioclase, in some specimens also magnetite. The groundmass is microcryptocrystalline to microcrystalline and seems to be composed chiefly of quartz and feldspar. Most of these rocks are considerably altered. The feldspars are clouded, and calcite, epidote, and limonite are abundant.

Pyroclastic rocks in association with the above rocks were found at all the localities. Those which are entirely clastic are designated tuffs. They consist of angular or subangular fragments of microcrystalline igneous rocks, quartz porphyries, andesites, and the like, of fragments of quartz and feldspar, and of crystals of quartz and feldspar all embedded in fine fragmental binding material whose nature is more or less obscured by its fine grain and by alteration. In some of these rocks there is notable uniformity in the size of most of the grains, in others there are grains of all sizes from fragments of several inches in diameter to submicroscopic grains. These rocks are all thoroughly indurated. Calcite, limonite, a little epidote, and serpentinous or chloritic material were detected in the matrix. Some of these rocks are distinctly stratiform. One such from Iliamna Bay, which is exceedingly fine grained, has a cherty appearance.

Other pyroclastic rocks, designated volcanic agglomerate, were found on Iliamna Bay and Ursus Cove. At the first-named locality there is a rock, composed of basic andesite or basalt, included in a matrix of amygdaloidal basaltic glass. The amygdules are of calcite and serpentine (?). On Ursus Cove the rocks of this class consist of fragments of altered feldspar, quartz, and of several kinds of microcrystalline igneous rock embedded in a base of cryptocrystalline eutaxitic lava.

Lithologic character in Lake Clark district.—Large areas around Lower Tazimina Lake and from there northward to Lake Clark are underlain by a group of rocks of porphyritic texture ranging in composition from acid rhyolites, through quartz porphyries, dacites, and mica andesites to intermediate hornblende andesites. Among these is a rhyolite (9AKz41) from a point 9 miles north of the mouth of Chekok River. This is a light-gray rock with small glassy quartz and white feldspar grains thickly studded in a lithoidal base. Under the microscope are seen phenocrysts of quartz, feldspar, and biotite. The quartz grains are generally without crystal outlines and many have "corrosion embayments." The feldspars include both orthoclase, slightly weathered, and plagioclase (about Ab_9An_1) quite fresh. These as a rule are euhedral. Biotite is less abundant than the quartz and feldspar and is considerably altered to chlorite. Numerous splinters of the above minerals are embedded in the groundmass, which is cryptocrystalline and shows flow texture.

Another of these rocks, at a point about 1½ miles southeast of the head of Lower Tazimina Lake, is a quartz porphyry (9AKz43), which is a dark felsitic rock in which minute quartz and white feldspar grains are macroscopically visible. The microscope reveals small abundant grains of quartz and acid plagioclase, commonly euhedral, and also a little biotite. The groundmass is a fine-grained intergrowth of quartz, feldspar, hornblende, and biotite. Small amounts of magnetite and apatite are present as minute crystals.

On the mountain 8 miles north of the mouth of Chekok River there is a dacite, a whitish light-gray microgranular rock (9AKz28), in which phenocrysts of feldspar are visible in the hand specimen. Under the microscope phenocrysts of acid plagioclase, biotite (much altered), and small magnetite grains are seen in a microgranitic groundmass of quartz and feldspar with small amounts of minute biotite and magnetite.

A hornblende andesite (9AKz35) from a point about 9 miles north of the mouth of Chekok River is a dense dark-gray rock in which small feldspars and hornblende grains are visible. Under the microscope plagioclase (about andesine so far as determinable) and hornblende are found as phenocrysts in a groundmass in which only plagioclase and magnetite are recognizable. Between these feldspar grains is an indeterminable base which is in part isotropic and may be glass.

The Roadhouse Mountain area is represented in the collections by an andesite (9M140) very fine grained and badly weathered (to which a rock (9M139) on Newhalen River is very similar) and a quartz porphyry tuff, consisting of fine angular fragmental quartz and feldspars in a seemingly fragmental binding material. These rocks are similar to some in the Tazimina area. Both of these specimens are from the southwest face of the mountain, and it is not known whether or not they are representative of the rest of the mountain mass, which was not examined.

These rocks usually have feldspar and sometimes quartz phenocrysts and rarely macroscopic ferromagnesian minerals. The groundmass, microcrystalline to cryptocrystalline and here and there eutaxitic, varies from bluish white or gray to black. Associated with these are tuffs, some composed of angular fragments of porphyry embedded in either a felsite or porphyry base, or again in a fine fragmental base, and others composed chiefly of fine feldspar crystals and fragments in a minutely comminuted base. The agglomeratic character of some is strikingly apparent, whereas others show it only faintly on weathered surfaces and still others resemble indurated grits or graywackes, and finally some which are light buff to purplish in color have soft sandy texture. These rocks seem to be related to one another as a succession of products of volcanic eruption. The various types in so far as any structures are discernible seem to lie in successive or alternating belts. This is particularly well shown on and near the mountain 8 miles north of the mouth of Chekok River, where a similar order of succession, gray dacite, eutaxitic vesicular vitrophyre, bluish felsophyre, and fine-grained black basalt is encountered on the southeastern and northern sides. About 5 miles south of Tanalian Point there are porphyries distinctly interbedded with tuffs, the whole formation there having a minimum observed thickness of 2,000 feet with uniform strike N. 65° W. (magnetic) and dip 25° NE. All these rocks are indurated but are internally undeformed and are altered only by weathering and cementation processes.

Fine-grained granular rocks occupy an area northward from the head of Lower Tazimina Lake for about 4 miles. These are of very fine grain, light color, usually with porphyritic texture and in many places miarolitic. They show considerable variation in appearance, and in the distribution of the different types of rock suggest a series of thick flows in approximately horizontal position. Mineralogically they consist of quartz, orthoclase, and acidic plagioclase with subordinate amounts of common hornblende or biotite or both. Hornblende in some is more abundant and important; others again are more basic, consisting only of plagioclase and pyroxene. These rocks should probably be considered part of the "porphyry and tuff" formation and not be grouped with the neighboring granites. They have about the same range in composition as the porphyries and tuffs, and though granitic they are generally also fine-grained, porphyritic, and miarolitic in texture, indicating crystallization under slight pressure, perhaps of thick flows at the surface. They seem to have the same bedded flow distribution as the porphyries and tuffs which they adjoin directly on the north and west. In the field only a part of them were recognized as granitic and they were provisionally mapped as identical with the porphyries and tuffs.

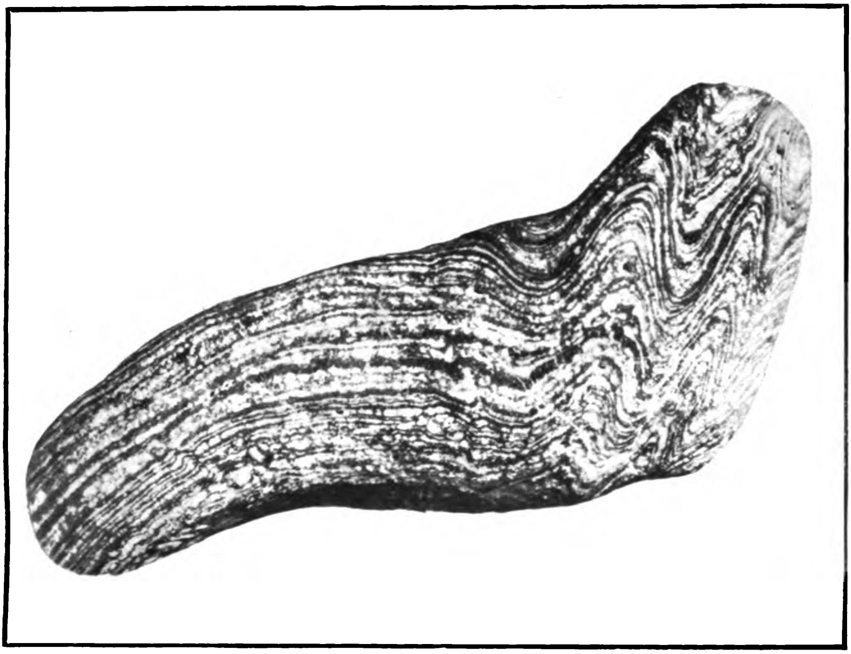
Summarizing, it may be said that these rocks range in composition from quartz alkali feldspar rocks with only small amounts of femic minerals to augite andesites. Their textures are usually porphyritic with aphanitic or exceedingly fine granular groundmass, and not infrequently flow structures are evident. Tuffs and agglomerates of like composition are intermingled with these rocks. Some are of coarse and angular grain which distinctly reveals their true nature, but associated with them, and in places connected with them by intermediate types (gradation phases), are considerable masses of dense aphanitic, light-colored, and banded rocks which were designated "chert" in the field but which on study appear to be thoroughly indurated pyroclastics of very fine grain.

In general these rocks as a group are not fresh. The feldspars as a rule are more or less completely kaolinized or saussuritized. The hornblendes and biotites are largely altered to chlorites and iron oxides, etc. Epidote, calcite, chlorite, quartz, and iron oxides (limonite) are abundant along fractures and in vesicles of the scoriaceous and tuffaceous members. The tuffs for the most part are thoroughly indurated.

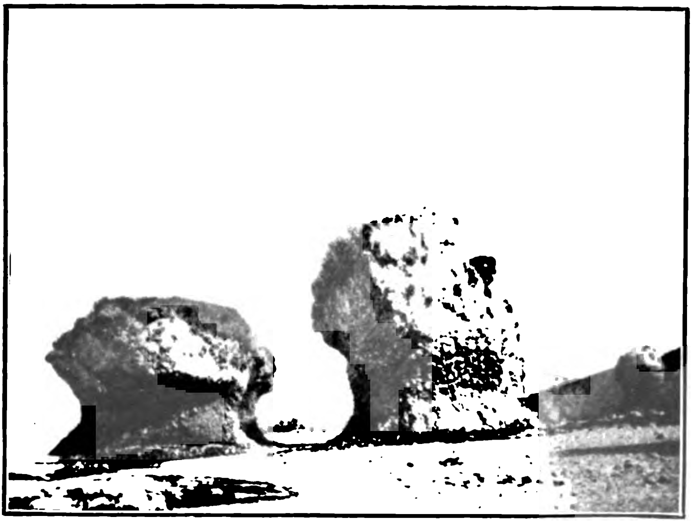
The southern part of the hill on the west shore of Lake Clark just above the mouth of Tlikakila River is occupied by rocks, part of which were regarded in the field as conglomeratic arkoses and part as porphyry breccia. These are light-colored, white and gray compact rocks, of which the constituents visible to the naked eye include, in some specimens, crystals and fragments of feldspar, and in other specimens bits of cherty looking material and of aphanitic porphyries which are generally rounded rather than angular. Three specimens under the microscope reveal material which is very much altered and fine grained and therefore of obscure relationships, but which indicates a tuffaceous rather than normal sedimentary character. In one rock, from the lake shore about a mile above Tlikakila River, bits of felsite and feldspar fragments, all more or less angular, are seen in a base too fine for determination. Another thin section of a rock near by shows small areas which, though obscure because of fine grain and decomposition, suggest in some cases micrographitic and in others eutaxitic porphyritic textures. Other areas in the thin section are a jumble of much-altered feldspar (largely plagioclase), quartz, pyroxene, and biotite (?) with accessory amounts of apatite, ilmenite, magnetite, and pyrite (?) in a fine-grained mat in which are quartz, limonite, feldspar (?), and other unidentifiable material. Secondary calcite is abundant. The rock has the appearance of decomposed volcanic agglomerate or flow breccia. A specimen from the summit of the hill is composed of euhedral, angular broken and corroded grains of feldspar (largely plagioclase), of euhedral and corroded quartz grains, of fragments of acid porphyritic rocks and iron oxide. All these are in a matrix composed of fine granular quartz (?) and much chloritic or serpentinous material and limonite. There are undetermined but unimportant amounts of other accessory and secondary constituents. This rock may with little doubt be classed as a dacitic tuff. In composition and degree of alteration these rocks seem to be more closely allied to the porphyries and tuffs of the area around the Tazimina Lakes than to any other rocks of the region, and as there is no proof of their stratigraphic position they are provisionally grouped with the early Mesozoic porphyries and tuffs for lack of a better place to discuss them.

Lithologic character in Iliamna Lake district.—The rocks of the third of these districts, which include the older volcanic rocks exposed on the south shore of Iliamna Lake, and possibly in some of the mountains west of Newhalen River, are quartz latites. They comprise the following types: (1) Light-gray or greenish-gray lithoidal porphyries in which there are sparse megascopic feldspars and pyroxene. (2) Gray, bluish, and light-brown glassy rocks which have as a rule a finely banded flow structure, which is both minutely contorted (Pl. VI, *A*) and bent in a large way. The flow bands are marked by lines of lithophysæ or spherulites or both. Some of these rocks are perlitic. (3) Light-colored gray, green, and browish tuffs of fine grain, in part distinctly banded and in part closely resembling the lithoidal porphyries.

The microscope shows that in these rocks the phenocrysts, which are not very abundant, include quartz, plagioclase (about labradorite), and rarely a pyroxene resembling diopside. One specimen contains a little brown hornblende. The groundmass where crystallized seems to be made up principally of small feldspar laths in rudely parallel aggregates. Minute apatites are common. That the tuffs and agglomerates associated with these rocks were derived from lavas of the same kind is indicated by the fact that the recognizable minerals in them are the same, namely, quartz, similar plagioclase, and similar pyroxene. Furthermore, there are fragments of finely crystalline rock very like the groundmass of the lithoidal porphyries.



A. BANDED RHYOLITE FROM SOUTH SHORE OF ILIAMNA LAKE.



B. CHISIK CONGLOMERATE.

Large blocks fallen from cliffs on east shore of Iniskin Bay.

Although these rocks in the field specimen not uncommonly have a weathered greenish or rusty appearance, they are quite fresh. Under the microscope only the more distinctly stratiform pyroclastics showed strong alteration of the feldspars. The femic minerals are very little weathered, and the groundmass is generally unaltered where crystalline; where glassy it is commonly still perfectly vitreous or but slightly devitrified. In the glassy and tuffaceous members vesicles and other openings are unfilled, although a rusty incrustation is common.

The rocks on the north shore of Iliamna Lake between Chekok and Knutson Bays, and of the islands off the mouths of Knutson and Pedro Bays, are probably to be grouped, in part at least, with the rocks described above from the south shore of Iliamna Lake. The rocks which were studied from the mainland between Chekok and Knutson Bays are of two types. One specimen proves to be a grayish-white porphyritic lithoidal quartz latite. Another specimen from this vicinity is a light greenish-gray agglomerate in which the recognizable constituents are bits of quartz, feldspar, mica, hornblende (?), and small pieces of granite. The indeterminate matrix somewhat resembles the quartz latite tuffs, but the rock is not improbably an arkosic conglomerate, as it was regarded in the field. Specimens from Low Island (the large island southwest of Pedro Bay) and two small islands north of it include (exclusive of the granites) three light-gray porphyritic lithoidal quartz latites. There is also a fragmental rock of light-gray base spotted with small feldspars and quartz grains, which are for the most part angular, though some are rounded, and with a few grains of undetermined minerals. This rock looks tuffaceous, but may be arkosic. Another fragmental rock of light-gray, fine, granular base, weathering rusty, contains large subangular pieces of granitic material and quartz. A third doubtful rock is white, rusty weathering, fine grained, and porous. There is no sign of rounded material, and the rock is most probably a tuff. On the south end of Low Island there is a dark waxy porphyritic glass of low specific gravity and a black vesicular porphyritic fine granular dike rock, probably a basalt.

It may be seen from the foregoing descriptions that there are two types of rock in this vicinity. One includes the quartz latites and their tuffs and the other includes the conglomeratic and arkosic rocks the matrix of which somewhat resembles the quartz latite tuffs. These were not separated in mapping, and the field relationships of the two were not determined. The quartz latites and their tuffs considered alone bear a close resemblance to the rocks described above (p. 56) under the same name from the localities on the south shore of Iliamna Lake, although the finely banded glassy rocks of the latter localities are here absent. If the conglomeratic and arkosic rocks are really as intimately associated with the quartz latites as the present grouping might be assumed to imply, then these rocks have, in this part of the district, a facies not recognized elsewhere. Another and perhaps the most probable interpretation of the conglomeratic and arkosic rocks would be to regard them as younger than the areally associated latitic rocks. The granitic constituents would then have a probable source in the near-by early Jurassic granite masses, and the tuffaceous constituents might well have been derived from the erosion of the latites. If this interpretation be adopted they might be correlated with the Middle Jurassic or Upper Jurassic conglomerates described below (pp. 59, 68) from the shore of Cook Inlet, or be regarded as a basal member of the Tertiary volcanic rocks (p. 78) outcropping near by on Iliamna Lake.

Age and correlation.—The rocks described above from the south shore of Cottonwood Bay overlie the Kamishak chert. The relationships are apparently those of conformable stratigraphic succession, for not only was no erosional break observed but there is a more or less gradual gradation in lithologic character from the fine-grained homogeneous cherty beds below to the coarser heterogeneous volcanic accumulation above. The local relationships thus indicate that these rocks are either very high in the Triassic or low in the Jurassic.

These porphyries and tuffs of Cottonwood Bay accord fairly well in their relation to the Upper Triassic Kamishak chert, as also in general lithologic character, with the tuffs and associated rocks, probably of Lower Jurassic age, which are typically exposed on the west side of Seldovia Bay[1] and probably extend continuously from that locality to Port Graham. These beds consist chiefly of water-laid fragmental igneous material, although cherty limestone is present in the section on the north shore of Port Graham. The thickness is probably more than 1,000 feet, but no good estimate could be made. These beds were referred provisionally by Stanton to the Lower Jurassic on the basis of the fauna obtained at Seldovia.

No Lower Jurassic faunas have been found west of Cook Inlet, either in the beds here described or in any others, but the volcanic beds described above from the west shore of Cook Inlet, and also those from Iliamna and Clark lakes may possibly be correlated with the beds at Seldovia, and assigned to the Lower Jurassic, on the evidence of similar lithology and sequence. This suggested correlation is regarded as probable for the rocks on Cottonwood and Iliamna bays. The assignment of the rocks west of the mountains to the Lower Jurassic is dependent on a correlation through the rocks on

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[1] Stanton, T. W., and Martin, G. C., Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 396–397. Moffit, F. H., Gold fields of the Turnagain Arm region: Bull. U. S. Geol. Survey No. 277, 1906, pp. 20–22. Grant, U. S., and Higgins, D. F., Preliminary report on the mineral resources of the southern part of the Kenai Peninsula: Bull. U. S. Geol. Survey No. 442, 1910, p. 167.

Iliamna Bay, and is hence doubly weak, since there is no very good local stratigraphic evidence on the age of the rocks on Iliamna Lake and east of Lake Clark or any definite proof that they are of the same age, or that any of them are synchronous with those on Iliamna Bay.

Comparison should also be made with the "andesitic greenstones, porphyries, and tuffs" described by Paige and Knopf[1] from the upper Matanuska Valley and by them referred to the lower part of the Middle Jurassic[2]; and with the Skwentna group of the Alaska Range.[3] The latter is known to underlie beds which carry the fauna of the Tuxedni sandstone (p. 63), and is possibly of early Middle or of Lower Jurassic age.

MIDDLE JURASSIC ROCKS.

TUXEDNI SANDSTONE.

Areal distribution.—The lowest known member of the Middle Jurassic of southwestern Alaska is the Tuxedni sandstone. This formation is typically exposed on the south shore of Tuxedni Bay, from which it is named,[4] and extends from there in a continuous belt, parallel to the general course of the shore of Cook Inlet, as far south as the east shore of Iniskin Bay, a distance of about 42 miles. Good exposures were seen on the south shores of Tuxedni and Chinitna bays and on the east shore of Iniskin Bay. It appears to be absent at the surface south of this point, probably being buried by Triassic and other rocks which are overthrust upon the Upper Jurassic beds. It probably extends north from Tuxedni Bay in line with its known outcrop southward, but the area of its probable position has never been visited by geologists. Beds correlated with these occur in other parts of Alaska, as will be described below.

Lithologic character and sections.—The Tuxedni sandstone consists of sedimentary beds of marine origin and is at least 1,100 feet thick. It is made up predominantly of sandstone, although it contains considerable shale and a few thin beds of limestone and conglomerate.

The basal contact of the formation is exposed on the south shore of the eastern arm of Iniskin Bay. The rocks of the Tuxedni sandstone at this point consist of fossiliferous sandstone and shale with beds of conglomerate containing pebbles, averaging several inches in diameter, of a variety of crystalline rocks, chiefly granite. The lowest of the several beds of conglomerate rests upon a sheared basic porphyritic rock which is regarded as a member of the Lower Jurassic(?) porphyries and tuffs. The conglomerate dips 50° SE.; the cleavage or bedding of the porphyry dips 34° NW. There is consequently either discordance of bedding between the porphyry and the conglomerate, or a structure in the former which is not developed in the latter. In either case the presence of an unconformity is established.

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[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 16–19.

[2] More recent evidence indicates that these rocks are of Lower Jurassic age. See Bull. U. S. Geol. Survey No. 500, 1912, pp. 29–32.

[3] Brooks, A. H., The Mount McKinley region: Prof. Paper U. S. Geol. Survey No. 70, 1911, pp. 85–87.

[4] The Tuxedni sandstone and the overlying Chinitna shale have formerly been grouped as the "Enochkin formation," which is here divided because of the dissimilarity of the lithologic character and faunas of the two parts.

The most complete known section of this formation is exposed on the south shore of the western arm of Tuxedni Bay. This section, measured by Stanton and Martin[1] in 1904, is typical for the lithologic and paleontologic character of the formation, although no exposure of either the base or the top is visible.

Section of part of the Tuxedni sandstone on south shore of Tuxedni Bay.

		Feet.
1.	Shaly sandstone with scattered fossils, *Inoceramus*, *Trigonia*, *Sphæroceras*, *Phylloceras*, etc	55
2.	Black sandstone with small white angular grains	8
3.	Hard gray sandstone	1
4.	Black sandstone with *Inoceramus ambiguus*, *Stephanoceras* cf. *humphriesianum*, *Sphæroceras oblatum?* etc	3
5.	Dark shale	8
6.	Soft coarse black sandstone with white grains	39
7.	Fine-grained gray shale with *Sphæroceras oblatum*, *Belemnites*, etc	18
8.	Fine-grained gray shale	35
9.	Bands of sandstone and shale	3½–6
10.	Dark soft shaly rock with coarse grains	10
11.	Dark limestone with abundant fossils, *Sphæroceras cepoides*, *Pleuromya*, etc	2–4
12.	Dark shale	3
13.	Dark conglomerate rock (arkose)	7½
14.	Dark shale with conglomerate bands	26
15.	Sandstone	1
16.	Gray shale	15
17.	Sandstone	2
18.	Shale with scattered fossils	12½
19.	Sandstone and shale with *Stephanoceras carlottense*, *S. richardsoni* *Sphæroceras cepoides*, *Lytoceras*, *Phylloceras*, and many other fossils	3–3½
20.	Shale with concretionary bands	10
21.	Concealed by a fault	±100
22.	Gray shale with numerous sandstone and concretionary bands and occasional fossils, including *Stephanoceras* cf. *humphriesianum*	100
23.	Gray shale with occasional sandstone and concretionary bands	150
24.	Gray sandstone with *Inoceramus ambiguus* and a few other bivalves	120

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[1] Stanton, T. W., and Martin, G. C., Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 399–400.

	Feet.
25. Limestone conglomerate with clavellate and undulate *Trigonias*, etc	1
26. Gray sandstone	3½
27. Dark gray fossiliferous sandstone	1
28. Gray sandstone with many small fossils	11
29. Fossiliferous conglomerate with *Belemnites*	2
30. Shaly sandstone with *Inoceramus lucifer* and *Lima* cf. *gigantea*	52
31. Sandy shale with a few thin indurated fossiliferous sandstone bands	35
32. Indurated ledges of argillaceous sandstone 1 to 4 feet thick, alternating with somewhat thicker beds of clay (fossiliferous)	25
33. Shale with abundant ammonites, *Stephanoceras*, *Harpoceras*, etc	20
34. Indurated bands of sandstone in ledges 1 to 1½ feet thick, alternating with thicker beds of shale	14
35. More or less sandy shale weathering yellowish	100
36. Sandstone with clay partings with abundant *Lima* cf. *gigantea*	36
37. Softer sandstone and shale to base of exposure, partly covered by shale talus	100
	1,128

This section is especially appropriate for the type section of this formation, because it not only shows the most complete known representation of these rocks but both marine invertebrates and fossil plants are present, the former in great abundance and variety. It was, moreover, measured at one of the first localities in Alaska at which a large collection of Jurassic fossils was made, and at which the fauna has long been known, not only through the early descriptions by Eichwald[1] but through the material subsequently collected by Dall[2] and described by Hyatt.[3]

The following section on the east shore of Iniskin Bay[4] includes the base of the formation, but the concealed intervals are very large, less than half of the beds being represented, and the contact with the overlying formation probably is cut off by a fault (see fig. 7, p. 99).

Section of Tuxedni sandstone on east shore of Iniskin Bay.

"Zone C."	Feet.
Sandy shales with many *Belemnites* and other fossils	50
Concealed	20
Soft shale	20
Dark-drab shale with scattered fossils	33

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[1] Eichwald, Eduard von, Geognostisch-palaeontologische Bemerkungen über die Halbinsel Mangischlak und die Aleutischen Inseln, St. Petersburg, 1871, pp. 88–200.

[2] Dall, W. H., Report on coal and lignite of Alaska: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, pp. 869–870.

[3] Hyatt, Alpheus, Report on Mesozoic fossils: Idem, appendix 3, pp. 907–908.

[4] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, 1905, p. 42.

	Feet.
Hard calcareous shale full of fossils, principally *Inoceramus*, *Pleuromya*, and other pelecypods	2
Black sandstone	1
Dark shale	5
Black sandstone	1
Dark shale with many fossils	12
Reddish limestone	½
Dark shale with many fossils	14
Dark shale with scattered fossils	62
Dark soft sandstone with streaks of conglomerate	10
Concealed.	
"Zone B."	
Shale with several fossil bands containing *Trigonia doroschini*, etc	50
Concealed.	
"Zone A."	
Shale with several fossil beds each 10 to 25 inches thick and packed with fossils; *Trigonia doroschini*, *T. devexa*, etc	30
Concealed.	
Shale	12
Coarse conglomerate	20
Unconformity.	

Fauna and flora.—The Tuxedni sandstone contains a large marine invertebrate fauna, which is still for the most part undescribed. The following lists comprise some of the more common species as determined by Stanton:

Marine invertebrate fossils from the Tuxedni sandstone.

South shore of Tuxedni Bay:
  Stephanoceras loganianum.
  Stephanoceras carlottensis.
  Stephanoceras cf. humphriesianum.
  Sphæroceras oblatum.
  Sphæroceras cepoides.
  Phylloceras sp.
  Lytoceras sp.
  Trigonia dawsoni.
  Lima cf. gigantea.
  Inoceramus ambiguus.
  Inoceramus porrectus.
  Inoceramus eximius.
  Inoceramus lucifer.
East shore of Iniskin Bay, zones A and B (2919):
  Belemnites sp. Fragments.
  Thracia sp.
  Trigonia doroschini Eichwald. Abundant.
  Trigonia sp. Belongs to Clavellatæ group.
  Grammatodon? sp. a.
  Pseudomonotis? sp.
  Pecten sp. A single very small, smooth form.
  Ostrea sp. Fragmentary specimens of a small irregular species.

East shore of Iniskin Bay, near lower cabin, zone C (2920):
Stephanoceras sp.
Belemnites sp. a.
Belemnites sp. b. Abundant.
Belemnites sp. c.
Grammatodon? sp. a.
Grammatodon? sp. b.
Inoceramus eximius Eichwald. Abundant.
The forms described by Eichwald as I. eximius, I. ambiguus, and I. porrectus may all belong to one species.
Pecten sp. Small form same as in lot 2919.
Pecten sp. Large individual that may be adult of last named.
Ostrea sp. Same as in lot 2919.

Fossil plants were obtained from several localities, at all of which they were interbedded with the marine sediments carrying the invertebrate fossils listed above. The following species have been determined by F. H. Knowlton:

Fossil plants from Tuxedni sandstone.

No. 915.—South shore of Tuxedni Bay:
Sagenopteris göppertiana Zigno.
Pterophyllum rajmahalense Morris.
Macrotæniopteris californica Font.
No. 916e.—South shore of Tuxedni Bay, 2½ miles west of Chisik Island:
Sagenopteris göppertiana Zigno.
Pterophyllum rajmahalense? Morris.
No. 916f.—South shore of Tuxedni Bay, 2½ miles west of Chisik Island:
Fossil wood, not studied.
No. 917h.—South shore of Tuxedni Bay, 3 miles west of Chisik Island:
Sagenopteris göppertiana Zigno.
No. 928.—East shore of Iniskin Bay "zone C:"
Sagenopteris göppertiana? Zigno.
No. 931a.—East shore of Iniskin Bay, 300 yards above lower cabin:
Sagenopteris göppertiana Zigno.

Age and correlation.—The fauna of the Tuxedni sandstone is regarded by Stanton[1] as showing that it certainly includes at least part of the Middle Jurassic, although he holds that further study of the faunas must be made before exact correlations with the European faunas can be made. Practically the same conclusion was reached by Hyatt[2] from his study of the fauna from Tuxedni Bay.

This fauna has been recognized in the upper end of the Matanuska Valley,[3] and also in parts of the Tordrillo formation of the Alaska Range.[4] The occurrence of this fauna in the Kennicott formation of the Copper River region is suggested by the reported presence there,[1] in the earlier but not in the later collections, of *Inoceramus eximius.*

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[1] Stanton, T. W., and Martin, G. C., Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 401–402.

[2] Hyatt, Alpheus, Report on the Mesozoic fossils: Seventeenth Ann. Rept. U. S. Geol. Survey, pt. 7, 1896, pp. 907–908.

[3] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, pp. 17–19.

[4] Brooks, A. H., The geography and geology of Alaska: Prof. Paper U. S. Geol. Survey No. 45, p. 232; The Mount McKinley region: Prof. Paper U. S. Geol. Survey No. 70, 1911, p. 90.

The only localities in North America, outside of Alaska, where a fauna similar to this has been found are in the "lower shales and sandstones (subdivision C)" of the "Cretaceous" of the Queen Charlotte Islands, where Whiteaves[2] has recognized many species belonging in this fauna.

The following discussion of the age and relationship of the flora has been submitted by F. H. Knowlton:

> The Jurassic plants, although few in species and not always well preserved, are of the highest possible interest, for they are found in intimate association with typical marine invertebrates of known Jurassic age. By combining the species found at the several localities we have the following lists:[3]
>
> Tuxedni sandstone:
>   - Sagenopteris göppertiana Zigno.
>   - Macrotæniopteris californica Font.
>   - Pterophyllum rajmahalense Morris.
>
> Chinitna shale:
>   - Cladophlebis denticulata (Brongn.) Sew.
>   - Ctenis grandifolia Font.
>   - Hausmannia sp.?
>   - Dictyophyllum cf. obtusilobum.
>
> The forms that have been specifically named are determined with a great degree of certainty, the most abundant being the *Sagenopteris*, which occurs at five of the eight localities. The two remaining forms are mere fragments that will not admit of specific identification, though there can be absolutely no doubt as to the correctness of the generic reference, especially that of the *Dictyophyllum*, which seems to be in fruit. As to the distribution of the named species, the *Cladophlebis* occurs in the Jurassic of England and France as well as other parts of the Old World, and, moreover, is very close to what has been called "*Asplenium*" *whitbiense*, which occurs abundantly in the Jurassic of eastern Siberia and California. The other four named species, not to go farther afield, are found in the "so-called" Jurassic at Oroville, Cal., but apparently have not been found in the Cape Lisburne region of Alaska, although the *Sagenopteris* is not greatly different from a species that is.

Knowlton[4] has also recently discussed the relationship of this flora to that of the Monte de Oro formation of California and its bearing on certain problems in the stratigraphy of Oregon and California.

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[1] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska, a special publication of the U. S. Geol. Survey, 1901, p. 50. Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. U. S. Geol. Survey No. 374, 1909, p. 31.

[2] Whiteaves, J. F., Mesozoic fossils: Can. Geol. Survey, vol. 1, 1876–1900, pp. 1–92, 191–262, 263–308. Dawson, G. M., Geological record of the Rocky Mountain region in Canada: Bull. Geol. Soc. America, vol. 12, 1901, p. 75.

[3] This discussion is based on not only the plants from the Tuxedni sandstone but also on those of the Chinitna shale, listed on p. 67.

[4] Knowlton, F. H., The Jurassic age of the "Jurassic fauna of Oregon": Am. Jour. Sci., 4th ser., vol. 30, 1910, pp. 49–50.

CHINITNA SHALE.

Areal distribution.—The Chinitna shale occupies a belt east of and parallel to the area of the Tuxedni sandstone from Tuxedni Bay to Iniskin Bay. It is well exposed on the west side of Chisik Island, on both shores of Chinitna and Oil bays, and on the east shore of Iniskin Bay. It has not been followed along the belt of its probable extension north of Tuxedni Bay. South of Iniskin Bay it does not appear at the surface within the area covered by this report, although it is known (p. 68) farther southwest on the Alaska Peninsula.

Lithologic character and sections.—The Chinitna shale is a lithologically rather homogeneous formation consisting of 1,300 to 2,400 feet of shale with subordinate amounts of sandstone and limestone. It rests with apparent conformity upon the Tuxedni sandstone, from which it is distinguished[1] by being argillaceous rather than arenaceous and by possessing distinctive faunas and floras.

The following section, measured by Stanton[2] on the north shore of Chinitna Bay, is typical of the lithologic character of the formation, although the base is probably not exposed, and no fossils were found in the upper 1,000 feet or more which is assigned to this formation on lithologic grounds.

Section of Chinitna shale on north shore of Chinitna Bay.

	Feet.
Indurated dark argillaceous shales with conspicuous thin bands and elongated lenses of yellowish impure limestone	500
At this point a change in the strike of the beds and in the direction of the coast carries the cliffs some distance from the shore. The section is continued on a small creek, which enters the bay about half a mile west of the end of the sea cliffs. Along this creek the exposures are not so continuous, nor so conspicuous as those in the sea cliffs, but they are sufficient to show the relation of the beds to the general section.	
Dark shales with occasional more indurated bands of argillaceous sandstone	425
Dark shales with beds of argillaceous sandstone forming many cascades. *Cadoceras* found near the middle	650
Indurated bands of argillaceous sandstone with abundant specimens of *Cadoceras* and *Belemnites*	10
Dark shales and argillaceous sandstones	115
Similar beds not well exposed	200
Dark shales weathering to brownish slopes with bands of small concretions containing *Cadoceras doroschini*, etc	75
Dark clay shales, weathering brownish, with concretions containing *Cadoceras* etc., near middle	110
	2,315

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[1] It was formerly grouped with the Tuxedni sandstone as the "Enochkin formation." See footnote, p. 59.

[2] Stanton, T. W., and Martin, G. C., Mesozoic section on Cook Inlet and Alaska Peninsula: Bull. Geol. Soc. America, vol. 16, 1905, pp. 400–401.

The section exposed on the east shore of Iniskin Bay, which is given below, has the top of the formation clearly defined and contains typical fossils throughout. The thickness of beds is much less than on Chinitna Bay. This is in all probability due to concealment of the base of the formation rather than to thinning.

Section of Chinitna shale on east shore of Iniskin Bay.

	Feet.
Dark-drab shale with numerous bands of limestone concretions filled with well-preserved specimens of *Cadoceras*, *Belemnites*, etc., and with occasional sticks of fossilized wood	146
Shale as above, partly concealed by talus at "Mushroom Rocks," thickness computed	77
Dark shales, as above, with same concretions and wood	196
Limestone	1
Shales, as above	363
Shales, partly concealed by talus, thickness computed	300
Shales, as above, with *Cadoceras doroschini* and a few other fossils	200
Concealed	25
	1,308

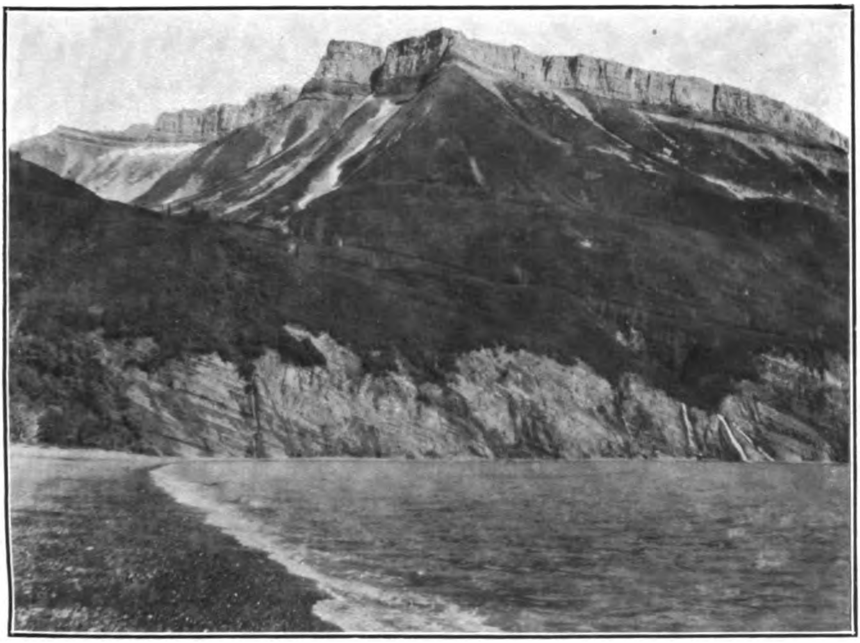
At Oil Bay, about 4 miles east of Iniskin Bay, the sequence and relations are practically the same as is shown in the following section. The beds represented in this section are shown on Plate VII, *A*.

Section of upper part of Chinitna shale on east shore of Oil Bay.

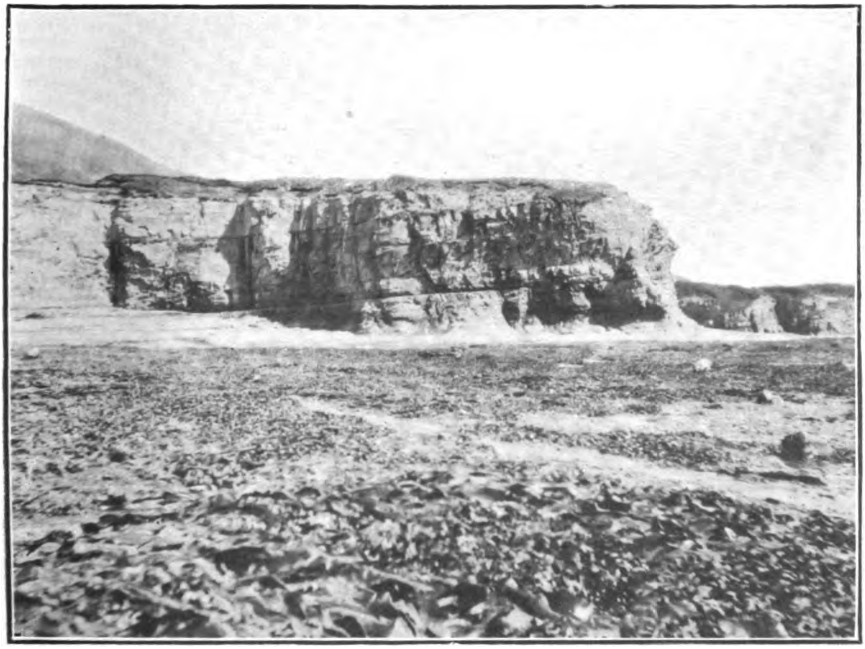
	Feet.
Dark shale with concretions	690
Hard dark sandstone	½–¾
Dark-drab shale with numerous concretions	530
Calcareous shale with *Cadoceras schmidti*, Pompeckj, *Cadoceras* sp. cf. *C. stenoloboide* Pompeckj, and *Phylloceras*	1
Dark shale with *Cadoceras doroschini*, etc	60
Soft green sandstone	½
Dark-drab shale	12
	1,294

The rock exposed at the extreme western point of Chisik Island contains an exposure of several beds of coarse conglomerate aggregating more than 100 feet in thickness, and occurring as a lens in the Chinitna shale. The stratigraphic relationships are clear at the northern end of the outcrop (see fig. 2), where some beds of the conglomerate may be seen ending abruptly against a vertical wall of shale, suggesting a fault, though others continue unbroken across this line, proving that no fault is present.

Fauna and flora.—The Chinitna shale is characterized by the presence of an abundance of large cephalopods, especially several



A. NAKNEK FORMATION AND UNDERLYING CHINITNA SHALE ON EAST SHORE OF OIL BAY.



B. HORIZONTAL SANDSTONE BEDS OF NAKNEK FORMATION ON WEST SHORE OF KAMISHAK BAY.

species of *Cadoceras*. These, with *Belemnites*, predominate over all other forms.

Invertebrate fossils from Chinitna shale.

No. 2921.—East shore of Iniskin Bay:
  Cadoceras doroschini (Eichwald). Abundant.
  Cadoceras wosnessenskii (Grewingk).
  Cadoceras schmidti Pompeckj.
  Cadoceras catostoma Pompeckj?
  Cadoceras sp.
  Macrocephalites? sp.
  Phylloceras subobtusiforme Pompeckj?
  Stephanoceras sp. Form figured by Eichwald as Amm. astierianus d'Orb. aff.
  Belemnites sp. a. One specimen.
  Goniomya sp. One small specimen.
  Lima sp.
  Pecten sp. Small smooth form.
  Pleuromya? sp. One specimen.
  Serpula? sp. Small discoidal form abundant in one rock fragment.
  Several undetermined bivalves represented by imperfect material.
No. 2941.—East shore of Oil Bay, 72½ feet above base of section:
  Cadoceras schmidti Pompeckj.
  Cadoceras sp. cf. C. stenoloboide Pompeckj.
  Phylloceras sp.

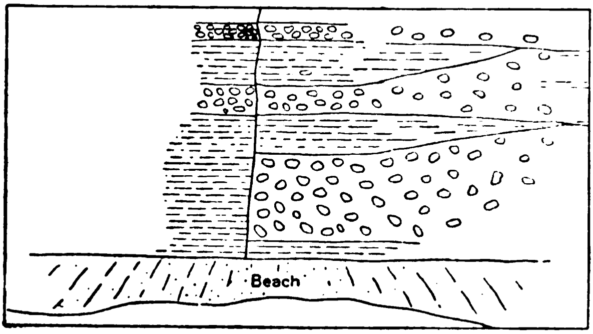


FIGURE 2.—Sketch showing conglomerate beds in the Chinitna shale on north end of Chisik Island.

A few fossil plants were collected from beds interstratified with those which yielded the ammonites. They have been identified by F. H. Knowlton as follows:

Fossil plants from Chinitna shale.

No. 929.—Iniskin Bay, east shore, ½ mile below lower cabin:
  Cladophlebis denticulata (Brongn.) Sew.
  Ctenis grandifolia Font.
  Hausmannia sp.? Mere fragment.
  Dictyophyllum cf. obtusilobum.
No. 929a.—Iniskin Bay, east shore, 1 mile below cabin:
  Fossil wood, not studied.

Age and correlation.—The fauna of the Chinitna shale is regarded by Stanton[1] as indicating the boreal facies of the Callovian stage, which belongs at the top of the Middle or at the base of the Upper Jurassic.

The only localities in Alaska, outside of those here described, where these beds or their fauna have been recognized are at Cold and Dry bays[2] on the Alaska Peninsula, and in the upper end of the Matanuska Valley.[3]

Its fauna shows close relationships with that of the Callovian of Russia, Franz Josef Land, and elsewhere in the northern as well as in other parts of Europe.

The evidence of the flora on the age and relationships of these rocks has been presented on page 64.

UPPER JURASSIC ROCKS.

CHISIK CONGLOMERATE.

Areal distribution.—The Chinitna shale is overlain on Chisik Island and on the east shore of Iniskin Bay by the Chisik conglomerate. This formation is probably of very local development, not having been recognized elsewhere within this region except probably on the east shore of Oil Bay, and possibly at the head of Kamishak Bay.

Lithologic character.—The Chisik conglomerate consists of a variable thickness of predominantly coarse conglomerate, composed of well-rounded pebbles of granite and other crystalline rocks in an andesitic tuffaceous matrix. The general appearance of large blocks of this conglomerate which have fallen from the cliffs on the east shore of Iniskin Bay at the locality known as Mushroom Rocks is shown in Plate VI, *B* (p. 56). The thickness of the conglomerate at Iniskin Bay is 290 feet, and is possibly somewhat greater, although it was not measured, at Chisik Island. It is probably represented by the 147 feet of fine-grained conglomeratic beds at the base of the section at Oil Bay recorded on page 72.

A thin section (3M15) of the matrix of the coarse conglomerate at Iniskin Bay showed the presence of rock fragments which are much altered, but which apparently were originally fine-grained basic rocks and angular fragments or crystals of feldspar and quartz, in a fine angular iron-stained fragmental matrix.

Age and correlation.—The age of the Chisik conglomerate is determined within approximate limits by the presence of Middle Jurassic faunas below it and of Upper Jurassic faunas above. In its lithologic character, and especially in the presence of andesitic tuffs, it is more nearly related to the rocks bearing the latter than to those bearing the former fauna, and hence it may be most reasonably interpreted as the basal conglomerate of the Upper Jurassic. Paige and Knopf have described a conglomerate of similar lithology and at about the same stratigraphic position, occurring in the Upper Matanuska Valley.[1]

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[1] Stanton, T. W., Succession and distribution of the later Mesozoic invertebrate faunas in North America: Jour. Geology, vol. 17, No. 5, 1909, pp. 411–412.

[2] Martin, G. C., The petroleum fields of the Pacific coast of Alaska with an account of the Bering River coal deposits: Bull. U. S. Geol. Survey No. 250, 1905, pp. 52–53.

[3] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, pp. 21–23.

NAKNEK FORMATION.

Areal distribution.—The Naknek formation occupies the west shore of Cook Inlet from Chisik Island to Iniskin Bay and much of the shore from the mouth of Iliamna Bay to a point about midway of the south shore of Kamishak Bay. The continuity of exposure is interrupted by older rocks on Tuxedni Bay, Chinitna Bay, Oil Bay, Iniskin Bay, Iliamna Bay, Ursus Cove, and Bruin Bay, and probably also near the head of Kamishak Bay.

Lithologic character and sections.—The Naknek formation which overlies the Chisik conglomerate, or in its absence rests upon the Chinitna shale, consists of about 5,000 feet of shale, sandstone, arkose, andesitic tuff, and conglomerate.

The following sections show the local lithologic character of this formation:

Section of Naknek formation on the north shore of Chinitna Bay.

	Feet.
1. Coarse conglomerate with 6-inch (maximum) granite pebbles and smaller pebbles of various lithologic character, in a tuffaceous or arkose matrix	10
2. Shaly arkose or sandstone	2
3. Conglomerate	2½
4. Arkosic sandstone or andesitic tuff	1½
5. Conglomerate	½
6. Massive tuffaceous rock with numerous inclusions	9
7. Tuffaceous rock with much shale	3
8. Andesitic flow or tuff	12
9. Shale	2
10. Concealed	10
11. Andesitic flow or tuff	15
12. Concealed	5
13. Contorted shale with large *Belemnites* at base	23
14. Sandstone	½
15. Shale	½
16. Andesitic flow or tuff	4½
17. Contorted shale with concretions	3
18. Arkose with granite pebbles at top	7
19. Sandy shale	2
20. Sandy shale with fossil band at top (*Aucella* bed)	3

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[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 21–23.

	Feet.
21. Dark shale	15
22. Conglomerate with shaly matrix	5
23. Sandstone	½
24. Conglomerate	3
25. Dark shale	4
26. Conglomerate with much shaly matrix	13
27. Agglomerate	9
28. Dark shale	20
29. Coarse conglomerate	2
30. Pinkish sandstone with pebble bands	2½
31. Conglomerate	5
32. Sandstone	¼
33. Shale	½
34. Andesitic flow or tuff	2½
35. Agglomerate	2
36. Andesitic flow or tuff	7
37. Sandstone with shale bands	8
38. Dark shale	25
39. Concealed (for 1,350 feet at 20° dip)	462
40. Andesitic flow or tuff	18
41. Concealed (for 100 feet at 20° dip)	34
42. Andesitic flow or tuff	10
43. Concealed (for 50 feet at 20° dip)	17
44. Andesitic flow or tuff	5
45. Concealed (for 130 feet at 20° dip)	44
46. Andesitic flow or tuff	32
47. Agglomerate	3
48. Arkose with shaly bands	19
49. Andesitic flow or tuff with agglomerate at base	55
50. Andesitic flow or tuff	30
51. Shale	6
52. Andesitic flow or tuff	79
53. Concealed (for 430 feet at 25° dip)	182
54. Agglomerate	63
55. Andesitic flow or tuff	185
56. Shale	1
57. Andesitic flow or tuff	158
58. Agglomerate	2
59. Andesitic tuff with abundant pebbles	60
60. Shale	4
61. Concealed (for 60 feet at 24° dip)	24
62. Sandy shale	68
63. Sandstone and shale	30
64. Andesitic flow or tuff	25
65. Concealed (across cove for 800 feet at 25° dip)	338
66. Coarse gray sandstone mostly heavy bedded	66
67. Alternating bands of sandstone and shale	7
68. Coarse gray sandstone	12
69. Concealed	10
70. Coarse gray sandstone	25
71. Shaly sandstone	4
72. Coarse gray sandstone	26

		Feet.
73.	Coarse gray sandstone with bands of fine conglomerate	5
74.	Coarse gray sandstone with thinner shaly bands	27
75.	Coarse gray sandstone with bands of fine conglomerate	162
76.	Fault. Displacement probably small.	
77.	Coarse gray sandstone with bands of fine conglomerate	50
78.	Dark shaly sandstone	25
79.	Alternating bands of shaly sandstone and fine conglomerate	10
80.	Coarse gray sandstone with bands of fine conglomerate	12
81.	Dark shale	2
82.	Coarse gray sandstone with fine conglomerate	21
83.	Dark shale with *Belemnites*	40
84.	Coarse gray sandstone	25
85.	Dark shales with thinner bands of coarse gray sandstone	100
86.	Massive coarse gray sandstone	60
87.	Coarse gray sandstone alternating with more shaly layers	125
88.	Covered, except two or three small outcrops of shaly sandstone	425
89.	Dark shale with *Belemnites*	160
90.	Cross-bedded coarse sandstone	30
91.	Dark shales and shaly sandstones with *Aucella*, etc	290
92.	Alternating bands of coarse gray and argillaceous fossiliferous sandstones	100
93.	Coarse gray sandstone	20
94.	Thin-bedded argillaceous sandstone in irregularly alternating lighter and darker bands	338
95.	Coarse gray sandstone	30
96.	Banded argillaceous sandstone with *Belemnites*	300
97.	Coarse gray sandstone with *Belemnites*	40
98.	Banded argillaceous sandstone	56
99.	Coarse gray sandstone and fine conglomerate	35
100.	Banded argillaceous sandstone with several fossiliferous beds, and a few thin bands of fine conglomerate	156
101.	Somewhat massive dark-gray argillaceous sandstone with a few thin yellowish bands	150
		5,139

This section is given in detail on account of the very great apparent thickness. Possibly part of this thickness may be due to repetition of the beds by faulting, but such repetition could not be detected, the observed faults being apparently small and unimportant. Fossils were not abundant, but the characteristic *Aucella*, resembling *A. pallasi*, was found sparingly 113 feet below the top and near the base of the section.

The following section on Oil Bay apparently does not contain representatives of the highest beds of the Chinitna Bay section. The massive beds in the upper part of the section are those which make the cliffs capping the mountain top shown on Plate VII, *A* (p. 66).

Section of Naknek formation on east shore of Oil Bay.

	Feet.
Naknek formation:	
Arkose, andesite, sandstone, conglomerate, and shale	2,000±
Sandy shale with *Aucella* near base	600
Shale with fossils	380
Coarse sandstone	3
Shale with *Cardioceras*, *Astarte*, etc	165
Concealed	40
Sandstone and sandy shale with *Lytoceras*, *Phylloceras*, and plant impressions	310
Naknek formation(?):[1]	
Conglomerate with an abundance of small pebbles $\frac{1}{12}$ to $\frac{1}{16}$ inch in length, and with numerous poorly preserved plant impressions	7
Sandy shale and sandstone	85
Conglomerate with pebbles as above	3
Shale	1
Fine conglomerate of same pebbles as above	7
Fine conglomerate of same pebbles as above, but interbedded with shale	14
Olive shale with an abundance of small pebbles, and with indeterminate fragments of a crustacean 5 feet above the base	30

The following section on Iniskin Bay represents only the lower part of the formation. The beds at this point are noteworthy because they include a considerable thickness of conglomerate, very similar in lithologic character to the underlying Chisik conglomerate.

Section of lower part of Naknek formation on east shore of Iniskin Bay.

	Feet.
Sandstone, arkose, shale, andesite flows, and conglomerate	270+
Dark sandy shale with *Aucella* in upper part	583

The beds described as andesite or as andesitic tuff in the above sections are composed of fragmental material. The microscope reveals fragments and crystals of plagioclase (some of which were determined to be basic), hornblende, biotite, and quartz and also some bits of fine-grained igneous rocks. All of these are predominantly angular in outline, but a few are rounded. The matrix in some specimens is distinctly fragmental; in others it is so fine and iron stained as to be obscure, but is probably also fragmental and composed of the same materials as the other specimens. In one specimen, slightly coarser than the rest, the larger grains are well rounded. The clastic, angular character of the grains of the rocks and their composition leaves no doubt that they are tuffs derived from andesitic lavas. The fragments of rock are too fine grained and too much weathered to be determined, but seem to be basic.

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[1] These beds are probably the local representatives of the Chisik conglomerate.

The exposures of this formation on the shores of Kamishak Bay differ somewhat in lithologic character from those represented in the above sections which are all north of Kamishak Bay. The dips are dominantly low in this part of the region and only a small part of the formation is exposed in the cliffs. These exposures are chiefly sandstone, the conglomeratic and volcanic beds not having been seen. Fossils (chiefly *Aucella*) are much more abundant than farther north. The type of beds exposed in this part of the region is represented on Plate VII, *B* (p. 66).

Fauna.—The fauna of the Naknek formation, according to Stanton, is especially characterized by the presence of one or two species of *Aucella* which are very closely related to and probably identical with *Aucella pallasi* and *A. bronni.* These fossils are at some localities very abundant, completely filling thick beds. Such localities are numerous on the south shore of Kamishak Bay. At other places they are so rare as to be easily overlooked, but in general a careful search will reveal them in one part or another of the section. Two or three species of *Belemnites* are associated with the *Aucella* at most localities. *Phylloceras*, a large *Lytoceras*, *Trigonia*, *Astarte*, and other pelecypods, and a few gastropods are present at some localities. *Cardioceras* cf. *alternans* and *Cardioceras* cf. *cordatus* were found in the lower part of the section on Oil Bay.

Age and correlation.—The stratigraphic position of the Naknek formation has been established by Stanton[1] as being clearly in the Upper Jurassic and not below the Oxfordian of the European geologists, the closest relationships with the European faunas being with the boreal Russian Volga beds.

In using the name Naknek formation for these rocks a definite correlation is made with rocks in the Alaska Peninsula on Naknek Lake and around Katmai where this formation was named and first described by Spurr,[2] and where he obtained a fauna consisting of *Aucella pallasi*, *Aucella* sp., *Natica* sp., *Belemnites* sp., *Terebratula* sp., *Avicula* sp., and *Astarte* (?) sp. The essential identity of this fauna with that obtained from the rocks here described, together with the strong similarity of the rocks in lithologic character, leaves little doubt that these beds are so closely related to those described by Spurr that they should be called by the same name.

This formation covers a broad area around the upper ends of Naknek and Becharof lakes and southeastward to Katmai and Cold Bay. This area possibly extends in a continuous belt northeastward to the head of Kamishak Bay, and may extend southwestward as far as Chignik and Herendeen bays, where Atwood[1] has found a similar fauna.

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[1] Stanton, T. W., Succession and distribution of later Mesozoic invertebrate faunas in North America: Jour. Geology, vol. 17, 1909, pp. 411–414.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 169–171.

The same fauna was found by Paige and Knopf[2] in beds of similar lithologic character in the upper end of the Matanuska Valley.

The same type of *Aucella* has also been found in the Kennicott formation[3] of the Copper River region.

The beds outside of Alaska which are related to these, according to Stanton,[4] are the Mariposa slate and equivalent formations of California and Oregon; the marine Jurassic of the Black Hills and Rocky Mountains, which represents apparently only the lower part of the Naknek; and the widespread boreal Upper Jurassic of north Europe, occurring in Russia, Spitzbergen, Nova Zembla, and elsewhere.

GRANITIC ROCKS.

Areal distribution.—Granitic rocks of considerable diversity of character, including granites of various kinds, granodiorite, and quartz diorite, occupy the greater part of the area of the Chigmit Mountains from the head of Bruin Bay northward beyond the heads of Lake Clark and of Tuxedni Bay. The rocks probably constitute one large continuous area with many smaller ones along its margins. Several of the latter were seen on Lake Clark. The position of the eastern border of the main mass of granite is known with certainty only at the heads of Tuxedni, Iliamna, and Bruin bays. The position of the western margin is known accurately only where it crosses the heads of Iliamna and Clark lakes. The northern end of the mass is probably far beyond the area which was mapped. The southern termination is probably at the head of Bruin Bay.

The margin of another mass was observed on the northern flank of Mount Douglas. This is probably the northern end of a large mass in the Aleutian Range, which is in all probability widely detached areally from the Chigmit Mountain mass, although it is doubtless closely related in lithologic character and period of intrusion.

Petrographic description.—There are many types of rock present, but by far the most abundant are hornblende granites and granodiorites. They are for the most part of medium grain, porphyritic habit, and light color, either light gray or pinkish. Mineralogically they are composed chiefly of albite or oligoclase-albite and quartz with either hornblende or biotite, or both. Apatite and magnetite are constant accessories. Orthoclase is not commonly a constituent of the rock and is nowhere important. The porphyritic habit is due to large crystals of feldspar.

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[1] Atwood, W. W., Geology and mineral resources of parts of the Alaska Peninsula: Bull. U. S. Survey No. 467, 1911, pp. 35–36.

[2] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 20–23.

[3] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska, a special publication of the U. S. Geol. Survey, 1901, p. 50. Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: Bull. U. S. Geol. Survey No. 374, 1909, p. 31.

[4] Stanton, T. W., Succession and distribution of later Mesozoic invertebrate faunas in North America: Jour. Geology, vol. 17, 1909, pp. 410–414.

Diorites composed of andesine feldspar, hornblende, biotite, and some augite are also less widely developed, but particularly between Iliamna Bay and Iliamna village. These diorites have considerable range in textures, from fine to coarse and from granitic to gneissoid.

At the mouth of Iliamna River, on the margin of the granitic area, are rocks ranging in composition from diorites to hornblendites, composed almost entirely of large hornblende crystals with very small amounts of feldspar, magnetite, and sulphides.

On some of the islands in Lake Clark, which are near the northwestern border of the granite, are augite diorites or gabbros composed of basic plagioclase, augite, and magnetite. These rocks may be marginal facies of the granite or independent intrusions. The latter conclusion seems indicated because other exposures in the vicinity and near the granite border, particularly those at the intrusive contact on Lake Clark above Tlikakila River, are of the types of granite more common in this region.

The granites are cut by numerous dikes generally only a few feet wide and chiefly porphyries of the granite or granodiorite family. One dike about 75 feet wide of very different composition was found near North Head on Iliamna Bay. This is a peridotite, considerably weathered where seen, apparently originally composed of enstatite, olivine, and magnetite or ilmenite, but now containing also much colorless amphibole, talc, and serpentine.

The most pronounced variation in composition and texture observed among these rocks is in the vicinity of the gneissic rocks west of Iliamna Bay. The granite is here much more basic than at other points and possesses a rough foliation not observed elsewhere. There is a strongly suggested possibility that granites of two types and ages are present; those neighboring the gneisses being intruded prior to at least part of the more intense deformation, while those on the flanks of the mountains were intruded subsequent to all but the later fault movements. An alternative, and in some ways the more attractive, hypothesis is that the granites are all of one general period and that the mountain range suffered part of its severer folding after the granites were intruded, this folding having been more severe in the heart of the range than on the flanks. Differences in composition would then find the most likely explanation in greater absorption from the invaded rock in the heart of the range.

The adoption of this hypothesis raises at once the question whether the gneisses and associated metamorphic rocks are really older than the sedimentary rocks flanking the mountains. The hypothesis may readily be extended to include the interpretation of the gneisses, schists, slates, and marble as locally intensely metamorphosed representatives of the unaltered Mesozoic sediments of neighboring subprovinces. This latter conclusion is, however, believed to be improbable.

Small porphyry dikes were seen on the shores of Iliamna Bay, and elsewhere, especially on the shores of Iliamna Lake and at the lower end of Lake Clark. They are younger than the granite and possibly belong to the Tertiary period of intrusion.

Age.—Regarding the age of at least part of the granitic rocks the evidence is conclusive even to a rather close time interval. Quartz diorite of the normal type for this region was intruded into the Upper Triassic rocks on Bruin Bay subsequent to their close folding. Near by are broad areas of Upper Jurassic rocks which were not involved in this close folding and which are not cut by the granites. Middle Jurassic rocks are nowhere on Cook Inlet known to be cut by granitic rocks. The granites cut the porphyries and tuffs of Iliamna Bay, which are Lower Jurassic or older, and probably also cut rocks of similar lithology on Tuxedni Bay and north of Mount Douglas. From this evidence it may be concluded that the granitic rocks are certainly younger than the Triassic and older than the Upper Jurassic, and that they are probably older than the Middle Jurassic and possibly younger than part of the Lower Jurassic. Further evidence is yielded from the presence of granitic bowlders in the Mesozoic sediments. The Chisik conglomerate at the base of the recognized Upper Jurassic contains bowlders of granitic rocks of the same types as the granites which occur in the mountain areas. The conglomerates in the lower part of the Chinitna shale on Chisik Island (p. 66) and at and near the base of the Tuxedni sandstone on Iniskin and Tuxedni bays also contain pebbles of granite. The evidence of these conglomerates is, however, of no value if there are areas of older granite near the gneiss west of Iliamna Bay. The age of at least some of the granitic rocks may, however, be safely placed in the Lower Jurassic. This conclusion should be compared with the conclusions of Brooks, Knopf, Spurr, and Atwood for the age of the granites of the Alaska Range, Talkeetna Mountains, and Alaska Peninsula.

The granitic rocks of the Alaska Range are, according to Brooks,[1] younger than the Tordillo formation, part of which at least carries the fauna of the Tuxedni sandstone, which is consequently very low in the Middle Jurassic. Younger rocks than these are not known in the vicinity of the Alaska Range granites, so the upper limit of the possible period of intrusion can not there be determined.

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[1] Brooks, A. H., The Mount McKinley region: Prof. Paper U. S. Geol. Survey No. 70. 1911, pp. 91–92.

In the Talkeetna Mountains and upper Matanuska Valley are quartz diorites which Paige and Knopf[1] state are younger than the "andesitic greenstones," which they regard as of Middle Jurassic age, and older than the Upper Jurassic.

The granitic rocks of the western flank of the Aleutian Range in the vicinity of Naknek Lake are described by Spurr[2] as including syenite and hornblende-biotite granite of pre-Jurassic age. The evidence of age consists in the presence of pebbles supposed to be derived from these rocks in beds of arkose which form part of the Naknek formation, now known to be of Upper Jurassic age.

In the western end of the Alaska Peninsula in the vicinity of Chignik and Herendeen bays the oldest rocks, according to Atwood,[3] are Upper Jurassic, and intrusives of the granitic type are absent. This may be accepted as corroborative evidence that the granitic rocks of southwestern Alaska are all pre-Upper Jurassic.

It should also be noted, however, that the granites of Alaska include intrusions of much broader periods than are represented in southwestern Alaska. Prindle[4] has determined some of the granite of the Yukon Valley to be Upper Cretaceous.

TERTIARY ROCKS.

SEDIMENTARY BEDS.

Areal distribution.—Tertiary sedimentary beds, excepting those which are intimately associated with the Tertiary volcanic rocks and are described below, are locally restricted to a locality on the north shore of Chinitna Bay near its mouth. Only a single small exposure in the cliffs is known. The beds are horizontal, and the relations to the neighboring exposures of the beds of the Naknek formation are concealed. There is no evidence as to the area of these rocks, but it can not be large.

Lithologic character.—The following section shows the stratigraphic sequence at this point.

Section of Tertiary rocks at mouth of Chinitna Bay, north shore.

	Feet.
Conglomerate with interbedded shale and sandstone	15
Dark shale	20

The shale at the base of the exposure contains several fossil tree trunks from 1 to 2 feet in diameter, at least two standing upright.

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[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, p. 20.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: Twentieth Ann. Rept. U. S. Geol. Survey, pt. 7, 1900, pp. 145, 232.

[3] Atwood, W. W., Geology and mineral resources of the Alaska Peninsula: Bull. U. S. Geol. Survey No. 467, 1911, pp. 26–27, 29.

[4] Prindle, L. M., The Fairbanks and Rampart quadrangles, Yukon-Tanana region, Alaska: Bull. U. S. Geol. Survey No. 337, 1908, pp. 26–27.

Numerous small sticks lie in the bedding of the shale. The tree trunks are silicified and show the structure of the wood very distinctly (922a).[1]

The contact of the conglomerate and shale is very irregular. The conglomerate also contains much fossil wood, partly lignitized and partly silicified (922b).

Above the lower bed of conglomerate comes a few feet of sandstone with shaly bands and lenses in which a few fossil leaves were collected (922c).

Obsidian was also found at this locality, apparently being interbedded with the Tertiary rocks. A thin section shows slightly devitrified glass containing rare quartz and feldspar phenocrysts.

Flora and age.—The fossils collected at Chinitna Bay have been identified by F. H. Knowlton as follows:

List of fossil plants from Tertiary beds at Chinitna Bay.

Nos. 922a, b.—Chinitna Bay:
  Coniferous fossil wood, not studied.
No. 922c.—Chinitna Bay, near entrance on north side:
  Ginkgo adiantoides (Ung.) Heer.
  Taxites olriki Heer.
  Populus sp.?
  Corylus macquarrii (Forbes) Heer.
Age—Arctic Miocene.

These beds are presumably the general equivalent of the Kenai formation of the east shore of Cook Inlet. They differ from those beds in degree of induration and in the presence of associated volcanic material, and probably bear a closer stratigraphic relation to the Alaska Peninsula type of beds carrying the Kenai flora. These latter beds occur just outside of the region here under discussion, being well developed in the vicinity of Cape Douglas.

BASALTIC FLOWS AND TUFFS.

Areal distribution.—Most of the shores of Iliamna Lake below the large islands at the mouth of Pile Bay, except those covered by sand and gravel, are made of basaltic rocks, including effusive sheets, tuffs, and probably some intrusive dikes and sills. A few thin beds of sandstone and shale were observed. These rocks cap all the high hills northeast of Intricate Bay, descending westward and reaching the lake shore just north of the end of the peninsula north of Intricate Bay. (See fig. 18, p. 109.) The basaltic rocks of this part of the area have a gentle westward dip but are not folded. The islands of Intricate and Kakhonak bays and the peninsula between them are likewise composed of basaltic tuffs, the basalt being prominently exposed in flat mesa caps where horizontal and in monoclinal strike ridges where steeply inclined. At most of the exposures the basalt shows the typical vertical columnar jointing characteristic of such sheets. Basaltic sheets also cap the high hills between Kakhonak Bay and Kakhonak Lake, many of the lower ridges being of conglomerate or conglomerate tuff. The latter rock is also exposed on some of the shores of Kakhonak Bay. These basic volcanic rocks with some interbedded conglomerate form the greater part of the south shore of Iliamna Lake from Kakhonak Bay west to a point about 25 miles east of the outlet of the lake. A few small outcrops protrude through the sands and gravels at scattered localities from here to the mouth of Newhalen River, from which point to the cape at the western side of Chekok Bay the shores and islands are entirely composed of these rocks except on the low beaches. Similar basalts and tuffs cap the high hills west of Newhalen River and Sixmile Lake. Basaltic masses, probably dikes or sills, occur at scattered points along the west shore of Lake Clark as far north as the head of Chulitna Bay.

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[1] The fossil wood described by Ward from "Iliamna Bay" (Mon. U. S. Geol. Survey, vol. 48, 1905, pp. 146, 147) possibly came from this locality.

Basalts, probably to be correlated with those already described, cap a group of high hills north of Chekok Bay and the low hill on the east side of Lake Clark about 7 miles northeast of Tanalian Point.

Petrographic character.—Sections of specimens of the basaltic rocks of Iliamna Lake, mainly taken from points on the south shore of the lake and neighboring islands, show them to be mostly augite andesites. They contain phenocrysts of plagioclase (labradorite and bytownite), common augite, and iron ores (magnetite and ilmenite), with abundant minute apatite. These are embedded in a groundmass which, where crystalline, shows the same minerals, which appear as phenocrysts. This groundmass varies in crystallinity from microophitic or microgranitic to a devitrified glass. Olivine was present among the phenocrysts of one section and possibly in another, a zeolitic amygdaloidal rock with opaque base and slightly weathered. As a whole these rocks are quite fresh.

A limestone breccia cemented by volcanic material was found at what is presumably the local base of these rocks at a point on the north shore of Iliamna Lake, 3 miles west of the mouth of Chekok River. This rock is composed of fragments of limestone and a few of quartz and other material embedded in a black matrix. Here and there in the rock are slightly rounded pieces; many more are irregular and angular in outline, but most of them are subangular. They range in size from a small fraction of an inch up to 2 inches in diameter, with few larger pieces. The majority are less than half an inch in diameter. The limestone fragments are of various colors, including white, light gray, pale bluish, salmon, and red. The few quartz fragments are white or salmon tinted, and the other unidentified materials are black or rusty red. The matrix is stony, dull, dark gray, or black. For the most part the fragments have a random arrangement, but in places flattish pieces are parallel. The grouping is in some parts close, in others dispersed so that the matrix constitutes a notable portion of the rock. In appearance the rock is striking and very like the particolored marble breccias ("Potomac marble") from the Triassic of Maryland. On the weathered surface of the rock there are pits, in places as deep as one-fourth of an inch, formed by solution of the limestone fragments. Even on comparatively smooth, wave-worn surfaces the larger limestone areas are slightly depressed. On the other hand the quartz makes little knobs. In rare instances the matrix is seen penetrating, for short distances, into cracks in the limestone fragments. A slight peripheral bleaching or discoloration was noted on two pieces of limestone. Very narrow rims of lusterless black material border some grains and a thin rusty streak fringes others. Study of a thin section of this rock shows the limestone to be made up of fine interlocking crystalline calcite grains which are not twinned. The matrix contains both opaque, black, lusterless material and pale yellowish transparent material. The latter is weakly birefringent or is made up of a cryptocrystalline aggregate of moderate or low birefringence. This material contains a few opaque grains with partial crystal outlines and with the color and luster of magnetite, and also a few minute bits of quartz (?). Around many of the limestone fragments are narrow fringes of twinned crystalline calcite, and there is also twinned calcite and limonite in cracks and cavities. That the matrix is a devitrified volcanic glass is suggested by its appearance under the microscope. This suggestion is strengthened by the peripheral discoloration of the limestone and the penetration of the matrix into the limestone as noted above.

The red basalts on the summits of the hills west of Sixmile Lake are porphyritic, having basic plagioclase and iron ores embedded in an opaque vesicular base in one specimen, and in a microophitic vesicular base of plagioclase, pyroxene, and iron ores in another specimen. These rocks are somewhat weathered, though the feldspars are still quite fresh.

The mountain 6 miles north of Chekok Bay is capped by fine-grained diabase or diabase porphyry. This rock contains, both as phenocrysts and in the groundmass, basic plagioclase, augite, and magnetite or ilmenite associated with apatite. Decomposition of the feldspars and augites of these rocks is common. They are more weathered than most of the other basaltic rocks, and are much broken by joints into small irregular blocks with rusty weathered surfaces. On the mountain 8 miles north of the mouth of Chekok River this rock lies above porphyries, and is probably in the shape of a nearly flat sheet. Its other geologic relations were not definitely discernible.

The rock on Lake Clark 7 miles northeast of Tanalian Point is petrographically very similar to that north of Chekok Bay. Here again it was found on the top of a hill whose base was porphyry and tuff. The relations were not determined.

Stratigraphic relations.—These rocks are considered to rest unconformably upon the rhyolitic lavas and tuffs already described. The chief evidence of the unconformity is the fact that the basaltic volcanic rocks are nearly everywhere flat or have low dips, while the rhyolitic rocks in most places stand at high angles. Along the south shore of Iliamna Lake from 15 to 25 miles below the head of Pile Bay the basalt caps the hilltops and is nearly flat, whereas the rhyolites outcrop along the shore, standing in many places at high angles. (See fig. 18, p. 109.) The same condition holds along the sides and base of the mountain 25 miles east of the lower end of Iliamna Lake. West of Sixmile Lake and Newhalen River, flat basalt sheets cap the hilltops and the rhyolites are below, but here the structure of the lower beds was not observed. The basaltic rocks are considered younger than the rhyolitic rocks, and to be mostly unconformably above, though in places intrusive into them.

Evidence showing the former to be the relationship was seen at Millet's prospects west of Chekok Bay, where along the beach and a short distance back from it are exposures of tuff, tuffaceous conglomerate, and lavas, which are considered part of the formation here described. The rocks in contact with them are older (Lower Jurassic?) volcanic rocks and Upper Triassic limestone. The contact of these older rocks with each other runs northward from a point near the shore. The younger volcanic rocks lap unconformably over both of these, their northern boundary running approximately east and west and intersecting the shore of the lake at the locality where the limestone breccia described on pages 79–80 was observed. At this point the breccia rests upon the upturned edges of the coral-bearing limestone (p. 42). It is considered to have been probably formed by a Tertiary lava flowing over and incorporating the rubble on the limestone surface.

Flora.—The sandstones which are probably at the base of the basaltic rocks have yielded small collections of fossil plants at two localities. These have been identified by F. H. Knowlton as follows:

Fossil plants from base of basaltic rocks on Iliamna Lake.

No. 4.—South shore of Iliamna Lake, 25 miles below head of Pile Bay (three-fourths of a mile southwest of Cache Point):
Corylus macquarrii (Forbes) Heer.
Taxodium distichum miocenum Heer.
Age—undoubtedly Tertiary.

No. 5.—South shore of Iliamna Lake, 29 miles east of outlet (2 miles west of Salmon Creek):
Taxodium or Sequoia sp.
Salix sp.?
Age—presumably Tertiary, but material pretty poor.

Age and correlation.—These rocks evidently correspond in position and age with the basaltic lavas and tuffs from the Talkeetna Mountains described by Paige and Knopf,[1] which are regarded as of late Tertiary age, and also with at least part of the Tertiary volcanic rocks of the Alaska Peninsula. They are also of the same petrographic type as the Recent lavas and tuffs of the now active volcanoes of Cook Inlet and the Alaska Peninsula.

QUATERNARY DEPOSITS.

GLACIAL DEPOSITS.

AREAL EXTENT.

Although glaciers once occupied the greater part of this region, as is shown by the general physiographic features, as well as by the presence of more minutely scoured exposures, the surface areas of unmodified glacial deposits, such as till, are rather small. In fact, such material was seen only in the immediate vicinity of the existing glaciers (see map, Pl. I) and in the lower part of the valley of Newhalen River, for short stretches at the base of the bluffs on the lower part of Iliamna Lake, and along the upper part of Kvichak River. It may be stated, in anticipation of conclusions reached below, that the general absence of till is explained in part by the fact that the glaciation was of alpine character and so vigorous that the glaciers and the glacial floods and mountain-side erosion, which accompanied and followed their extinction, obliterated in large part their constructive products, and in part by the fact that drowning of the lower glacial sites, during and subsequent to the retreat of the ice, buried the larger accumulations of moraine beneath younger water-laid deposits. It follows from the latter condition that glacial deposits have a much wider extent beneath the terrace and alluvial deposits than they have at the surface.

CHARACTER OF THE DEPOSITS.

Good exposures of glacial till were seen on the north shore of Iliamna Lake, from 13 to 16 miles west of Newhalen River. The best of these exposures is represented in the following section:

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[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: Bull. U. S. Geol. Survey No. 327, 1907, pp. 29–30.

Section on north shore of Iliamna Lake, 15 miles west of Newhalen River.

	Feet.
Dune sand	1½
Stratified gravel	8
Stratified sand, very fine grained	17
Glacial till to lake level	32

The upper surface of the glacial deposits in these exposures is clearly marked by the abrupt change in lithologic character from the cleanly washed and well-stratified material above to the heterogeneous mass of unsorted material below. The till consists of unweathered sticky clay in which is embedded a great variety of material, ranging in grain from sand to blocks of rock several feet in dimension, and including rounded, faceted, and angular pieces of rock typical of most or all of the more resistant kinds seen in outcrop on Iliamna and Clark lakes. The contact between the morainic accumulation below and the stratified beds above is also marked by a line of springs caused by the porosity of the upper and the relative imperviousness of the lower beds. The upper surface of the till slopes westward, passing below the level of the lake, near the cape, 16 miles below Newhalen River. The local slope of the upper surface of the till appears to be about 30 feet per mile.

The best exposures of till on the Kvichak River are about 7 miles below the outlet of Iliamna Lake. The till here occupies most of the river bluffs, apparently being capped by a thin layer of stratified gravel and sand. The fact that the till here rises to a greater height than at the locality described above on the north shore of Iliamna Lake is regarded as caused by the presence at this point of a high ridge of terminal moraine, marking a long resting stage in the retreat of the Iliamna Lake Glacier, if not the position of its ultimate front.

Unmodified glacial deposits also were seen in the lower part of the Newhalen Valley, from 2 to 5 miles from the shore of Iliamna Lake. The character of these deposits is indicated by the hummocky surface typical of morainic topography. No sections of the beds were exposed.

CONDITIONS OF DEPOSITION.

Existing glaciers.—The existing glaciers of this region are not nearly as numerous as in other coastal parts of southern Alaska and they are not large. Only in the vicinity of Mounts Iliamna and Douglas, and outside of the area covered by the actual mapping, are there large unbroken areas above snow line which are competent to form the gathering grounds for extensive glaciers. Within the district shown on the map the areas above snow line are individually small and much broken up by lower valleys, and the glaciers are consequently limited in extent.

All of the larger streams tributary to Lake Clark near its head have their sources in glaciers. Most of these are, however, outside of the area mapped.

The four northernmost valleys on the east side of Lake Clark, above a point opposite the mouth of Tlikakila River, contain glaciers descending from the snow fields about 6,000 feet above tide. The smallest, something less than a mile long, descends to about 4,400 feet, while the northernmost and longest sends a very narrow tongue down to 2,000 feet about 2 miles below the cirque.

The valley of Currant Creek contains one or two very small glaciers, which were seen but not mapped, and is reported to contain a larger glacier farther east.

Near the head of the Kontrashibuna drainage there are 15 glaciers shown on the map, all just below the crests of northward-facing slopes. Just beyond the mapped area are many more. The lowest of these lies at an altitude between 3,400 and 4,800 feet, approximately, but most of them are between 4,000 and 5,000 to 5,800 feet. The largest is barely a mile in extreme length.

Another very small glacier is about 12 miles north of the head of Pile Bay, on the northwest face of the ridge west of Pile River. It lies between 3,500 and 4,500 feet above tide.

One of the smallest of all the glaciers of this region is about 3 miles west of the head of Iliamna Bay, and between the Iliamna and Hicks trails. It lies in the head of a gulch on a north slope at an elevation of about 3,000 feet.

The snow fields around Mount Iliamna send out several valley glaciers of fair size. Three of these go out to the south and are tributary to streams entering Chinitna Bay. They are known as East, Middle, and West glaciers. Another good-sized valley tongue goes out to the north and is tributary to the unnamed stream at the head of Tuxedni Bay. Several other glaciers of this type must flow west from these snow fields, but nothing is known of their position or size. The abundance of glacial silt in the waters of Iliamna and Pile rivers and of all the larger streams east of Lake Clark is conclusive evidence of the existence of many glaciers in that region.

The high country around Mount Douglas and the neighboring peaks at the north end of the Aleutian Range is the feeding ground for many glaciers. Seven or eight large glaciers, several of which reach almost to tidewater, are known to radiate from the snow fields in that locality.

The distribution and size of the existing glaciers appear to be governed primarily by the extent of large unbroken areas at high altitudes. The information at hand does not warrant a positive conclusion as to whether there is within this region a geographic difference in degree of glaciation independent of that based upon the extent of the high level areas. Such a further difference in present intensity of glaciation would be expected from the differences in temperature and precipitation which are believed to exist between the eastern and western sides of the Chigmit Mountains, but the actual observations on position of snow line and size of glaciers in the different parts of the region are not sufficient to positively confirm the conclusion that such is the case. It is an undoubted fact that the glaciers descend to lower altitudes in the Cook Inlet drainage than in the Bering Sea drainage, but this finds a possibly sufficient explanation in the fact that the divide lies well toward the eastern boundary of the mountains so that the eastward gradients are far steeper than the western.

Former glaciation.—The existing glaciers are insignificant in size and number in comparison with the recent but earlier and more extensive glaciers. The presence of these glacierlets therefore does not permit the positive conclusion that conditions now favor the development of glaciers in all of the areas of this region which they now occupy. It is perhaps rather to be supposed that some of these are but dying remnants of the earlier glaciers.

All the larger valleys of the region, and east of longitude 154° 30′ almost every considerable valley and even the inconspicuous gulches on the northerly slopes of the higher divides have been occupied by glaciers. This is evident by the U-shaped cross sections, the glacial scouring and débris, and the cirques. The glaciation was strictly alpine, that is, the glaciers were confined to and directed by preglacial drainage lines. As a result the higher interstream areas are unglaciated, whereas the lower portions of the valleys have been modified by glaciation, so that a striking topographic unconformity has been developed. In the higher nonglaciated interstream areas there are uniformly well developed, fairly mature, open V-shaped tributary valleys with sharp ridges intervening. In the lower areas are almost plane slopes on which the tributary streams are either not at all intrenched, or are but slightly incised in narrow gorges. The character of these two physiographic types is well shown on Plate VIII, *A*, page 86. In some places the development of the glaciated type of physiography has been due to the truncating or complete erosion of the ends of the minor interstream spurs, leaving the sides of the major valleys in which the glaciers moved, steeper than the unglaciated parts and smooth and regular up to the height of the former ice surface. In other places the lower areas have been filled with glacial débris and their slopes have been decreased. The preglacial topography which remains at higher altitudes has at lower altitudes been effaced, in one case by degradation, in the other by aggradation. The truncation of interstream spurs is well shown on the west of the Tlikakila River and on Tanalian

Mountain. The filling and mantling of preglacial topography is seen to advantage on the south face of the mountains north of Chekok Bay.

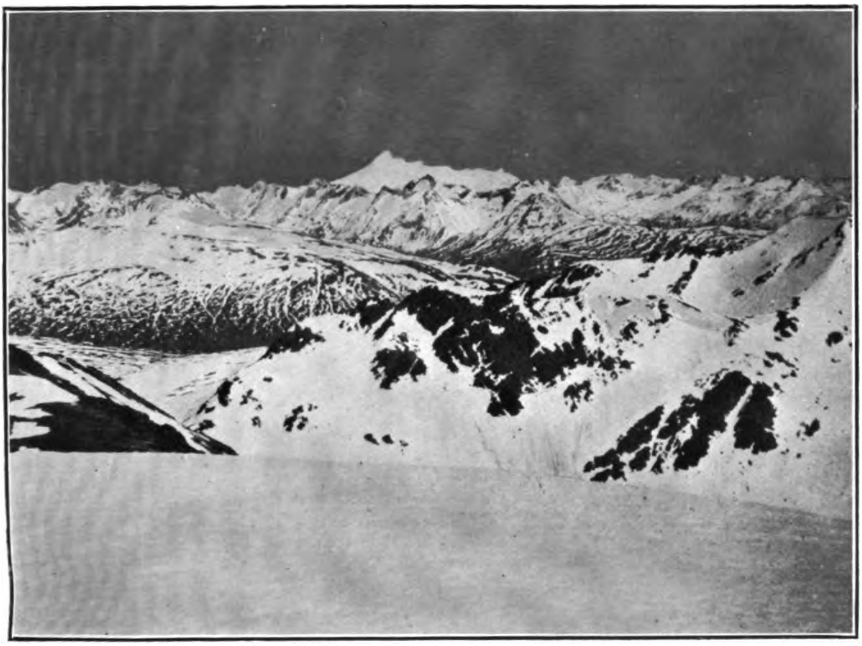
The Lake Clark valley received large ice streams from the valleys of Tlikakila and Chokotonk rivers and Currant Creek. The gathering grounds for these glaciers lay mainly to the east of the region mapped. Ice entered Lake Clark valley from Kontrashibuna Valley through the valley of Tanalian River, and possibly also through the pass east of Tanalian Mountain. Kontrashibuna Glacier received tributary ice streams from dozens of cirques all along both sides of its course, except from Tanalian Mountain, which faces south, and also from a great number of cirques in the high mountains on the edge of the mapped area and eastward. Two or three small glaciers also came out from small valleys below Takoka Creek. There is no good evidence that there were, to the west of these, other ice streams tributary to Lake Clark from the east, and on the west side of Lake Clark there was apparently none below Tlikakila River. It is a noteworthy fact that, in the upper part of Lake Clark valley, the mountains east of the lake are clearly shown by their physiographic character to be glaciated to a considerably greater height than the mountains on the west side of the lake. This is regarded as evidence that the bulk of the glacial flow came from the east and that the valley of Lake Clark existed prior to the glacial invasion and deflected the westward glacial flow from the Chigmit Mountains so that large areas west of the lake were not overridden.

The Tazimina Valley glacier received its ice chiefly from the mountain area at the head of the drainage basin. There was one important tributary from the southeast entering at Chekok Pass and many small ones from the south valley wall. Ice lay in the col on Chekok Pass and probably moved northward at times and at other times southward.

Knutson Creek glacier headed against the area tributary to Tazimina Glacier with which it was probably merged in the ice that lay in a col between the two drainage basins. Along the present Knutson Valley, 10 small tributary glaciers entered from the east, but there were none from the west.

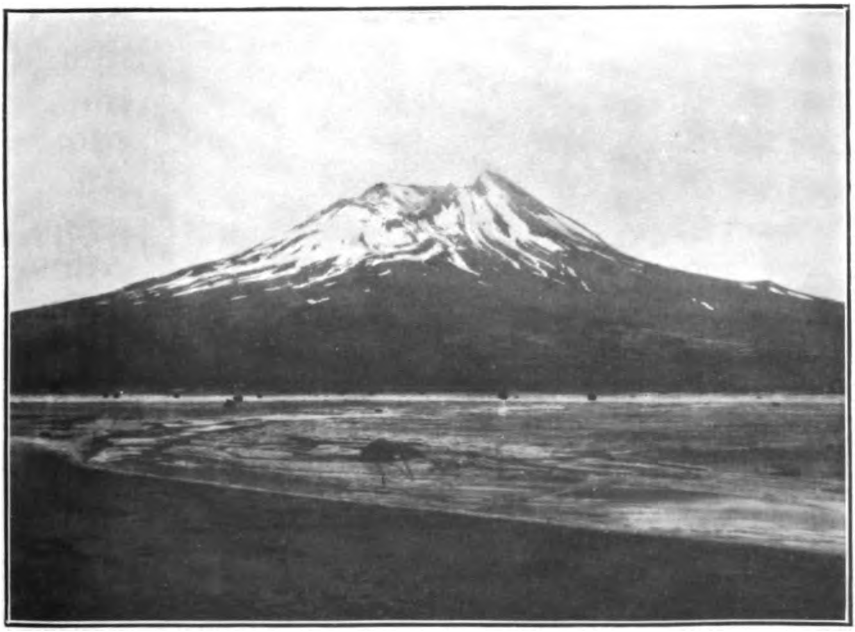
Pile River glacier headed beyond the mapped area. About 4 miles above the head of Pile Bay it received a large glacier from the northwest whose feeding grounds adjoined that of the Tazimina Glacier, and also lay on the westward-facing slope of the ridge west of the lower part of the valley of Pile River.

The valley of Iliamna River was occupied by a glacier formed by the fusion of glaciers in the north and south fork. The former was fed mainly beyond the limits of the district mapped. So also in part was the latter, but it received many small glaciers from the area



A. ACCORDANT MOUNTAIN SUMMITS.

Showing Mount Iliamna rising above them and smooth glaciated slopes below. Looking northeast from point near head of Pile Bay.



B. MOUNT AUGUSTINE FROM THE WEST.

between it and Chinkelyes Creek. The valley of this creek received many small glaciers which united and flowed down to Iliamna. The Iliamna and Pile River glaciers overrode the ridge separating their lower courses and there united. About a mile or two northeast of Pedro Bay this ice stream joined that coming down Knutson Bay.

At the headwaters of Kakhonak River and in the neighboring valleys were a number of glaciers. Their extent and distribution is not well known, but most of them probably united in the main valleys and extended as low tongues to Iliamna Lake basin, where they met the ice streams from further northeast.

The lower end of the Lake Clark glacier perhaps sent a lobe up the Chulitna Valley and up the valley entering the extreme southwest corner of Lake Clark. Another lobe entered Kokteekish Pass to meet one from the Tazimina Glacier. The main mass of ice probably moved through the basin of Sixmile Lake and Newhalen River, there receiving the Tazimina Glacier and continuing to the Iliamna Lake basin, where it united with other ice streams from the northeast and east. In the lower part of the Iliamna Lake basin the combined glacier with a width of from 35 to 40 miles extended at least as far as the present foot of the lake.

Iniskin and Iliamna bays and Ursus Cove, all received glaciers from the valleys entering them. At the mouth of Iliamna Bay the mountain sides are glaciated up to an elevation of at least 1,000 feet. Therefore it is probable that these glaciers rode a little distance out into what is now Cook Inlet, but whether into open water or to join a large glacier filling the Cook Inlet basin is not known.

The glaciers filling the major valleys to considerable depths, in several instances blocked, without themselves filling, tributary valleys. Such, for example, are the valleys entering Lower Tazimina Lake from the north and those directly north of this point which enter Lake Clark from the southeast. The passes between the two lakes by way of these valleys have flat gravel floors, the one in the pass 7 miles east of Kokteekish Pass being at an elevation of 1,900 feet. These valleys were blocked by the ice of the Lake Clark and Tazimina glaciers and were probably filled by both outwash from the glaciers and by the mountain débris carried down the tributary gulches. Whether these deposits were laid down in dry or in water-filled basins could not be determined, for even where postglacial erosion has gullied and terraced these deposits they are mantled by grass and small shrubbery. It, however, seems probable that these blocked valleys held ponds.

Similar deposits (fig. 3) were found in the valleys of the streams entering Lake Clark 7 and 5½ miles below Tanalian River. In the latter valley the gravels seem to have formed a broad floor about 2,400 feet above tide in the basin at the forks of the stream and to have extended through a col to the valley of the next small stream to the north. Recent erosion has terraced this deposit, leaving only remnants at the higher elevations here and there on the valley walls. In its lower course the stream has cut a gorge 300 feet deep in these gravels. The valley east of the mountain 7 miles north of Chekok is another one which is thus filled because of a former ice dam.

The height of these gravels in blocked valleys affords one clue as to the summit of the glaciers. Along the south side of Lake Clark this appears to have been about 2,000 feet at Kokteekish Pass and 2,400 feet at a point about 4 miles below Tanalian Point. These figures correspond with the height of glacial erosion on the mountain sides along Lake Clark. Farther up the lake the high gravels were not seen, but the height of the ice is well marked by the maximum height of the truncated mountain spurs. By this criterion the ice in the vicinity of the mouth of Tlikakila River was about 3,000 feet above tide. The thickness of this ice stream must have ranged between 2,500 and 3,500 feet. The slope of the ice surface, according to these figures, was nearly 30 feet to the mile in the valley of Lake Clark. In the other larger valleys, including those of Kontrashibuna, Tazimina, Pile, and Iliamna rivers, evidence for the determinations of the thickness of the ice is not so reliable as that on Lake Clark. But it is probable that the ice lay in these valleys up to elevations of about 3,000 feet at their heads and about 1,800 feet near their mouths. These statements of course apply only to the large composite ice streams in the master valleys. The tributary and head glaciers lay at elevations above 3,000 feet up to 6,000 feet, descended over steep gradients, and were not so thick. Over the lowlands around Roadhouse Mountain and Chekok Bay, where the Clark and Tazimina glaciers and those from the east met, they spread out notably, and as would be expected the upper limit of glaciated surfaces and glacial débris descends to about 1,400 feet. In the still broader basin of Iliamna Lake, which received practically all of the glacial ice of the region, the glacier deployed considerably and its surface stood at a still lower elevation.

TERRACE GRAVELS.

AREAL EXTENT.

Broad areas on the shores of Lake Clark below Currant Creek, on the north shore of Iliamna Lake west of Chekok Bay, and on the south shore of Iliamna Lake for 25 miles east of the outlet are covered with stratified gravels and sands. The same deposits extend throughout the Kvichak Valley and the Bering Sea coastal plain. These deposits occur in minor development in other parts of the region, but are there conspicuous for their small and irregular extent. On the west shore of Cook Inlet they were seen on the north shore of Ursus Cove at the mouth of the valley heading near Cottonwood

Bay, and on the neck of land connecting the peninsula at the mouth of Bruin Bay with the mainland.

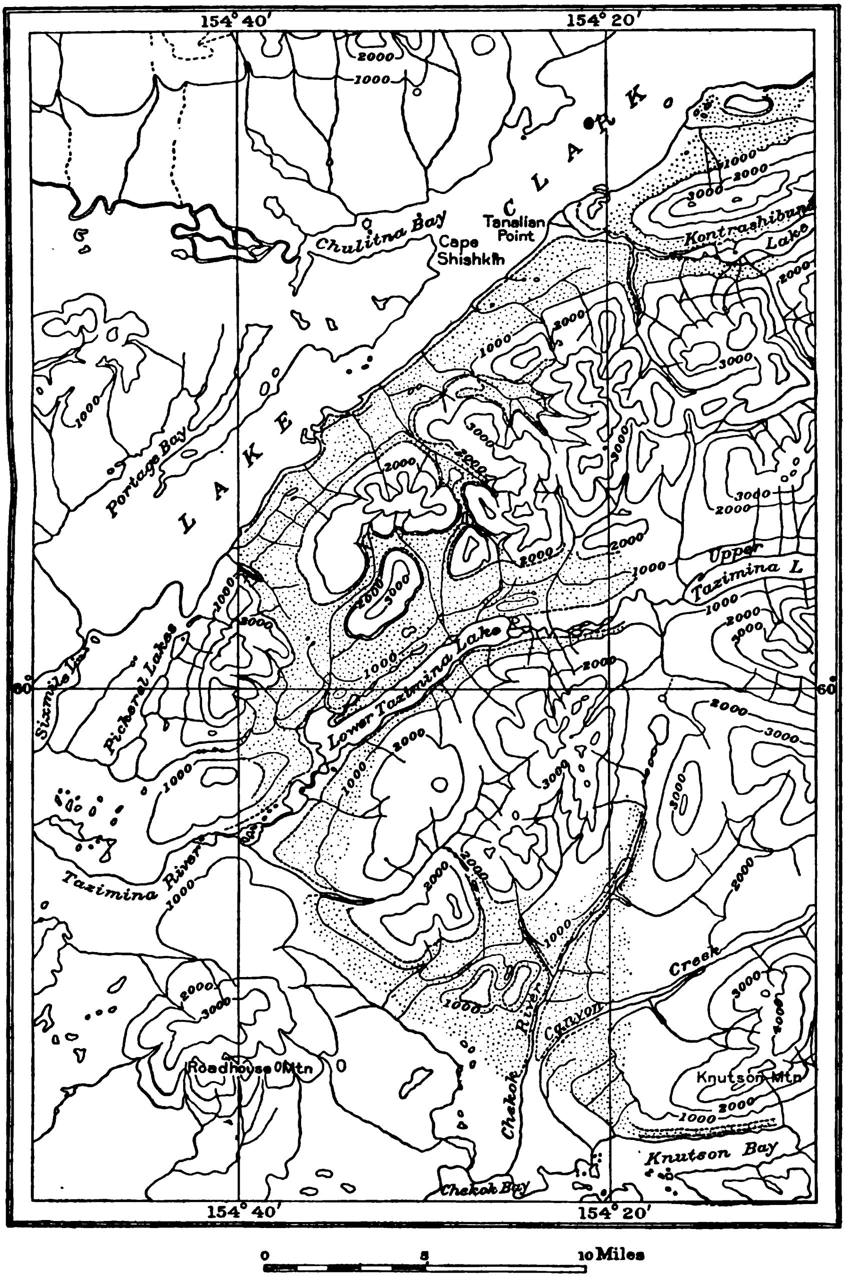


FIGURE 3.—Map showing observed distribution of the higher gravels southeast of Lake Clark.

The areal extent of the better-developed terrace gravels at lower altitudes is shown on the geologic map (Pl. II). These are regarded as having been deposited in estuarine waters and are consequently, in general, uniformly well developed and conceal the hard rocks over broad areas. Other gravels (pp. 87–88, 91–92) at higher altitudes, which also occur partly in terraces, were mapped in part of the region. The areal extent of these, as far as mapped, is shown on figure 3, page 89.

CHARACTER OF THE DEPOSITS.

The character of these beds, as exposed in the bluffs on the shore of Iliamna Lake, is well shown in the following sections:

Section of terrace deposits on north shore of Iliamna Lake, 18 miles west of Newhalen River.

	Feet.
Sand and gravel in thin beds of diverse character and degree of homogeneity	6
Gravel, containing pebbles one-half to 1 inch in diameter, roughly to smoothly rounded	12
Sand, very fine-grained and cross-bedded	30
Concealed to lake level	12

Section of terrace deposits one-half mile east of the last.

	Feet.
Dune sand with much vegetable material	8
Fine gravel with pebbles about one-half inch in diameter	5
Sand, very fine grained, with suggestion of wind-bedding, and in places with iron crusts	30±
Concealed to lake level	10

Section of terrace deposits on north shore of Iliamna Lake, 16 miles west of Newhalen River.

	Feet.
Dune sand	31
Gravel	10+
Fine sand to lake level	42

The section given on page 83, which is 1 mile east of the last, also shows the character of these deposits and of their contact with the underlying beds.

The deposits exposed on the south shore of Iliamna Lake 15 miles east of the outlet are composed of fine sand with poorly defined stratification, containing pebbles and bowlders of many igneous rocks, including granite, porphyry, rhyolite, basalt, and tuffs of various kinds.

Numerous remains of a mammoth were found by A. L. Pinart in the bank of Kvichak River. Paleontologic descriptions of the material have been published by Gaudry,[1] but no information was given concerning the exact locality or the character of the beds containing the remains.

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[1] Gaudry, A., Sur une dent d'*Elephas primigenius*, trouvée par M. Pinart dans l'Alaska: Compt. Rend. Acad. Sci., Paris, vol. 75, 1872, pp. 1281–1283; Sur une dent d'*Elephas primigenius*, trouvée sur la rivière Koultchak, dans l'Alaska: Voyages à la côte nord-ouest de l'Amérique, Paris, 1875, pp. 29–31, Pl. A.

The surface of these beds is beautifully terraced, well-marked benches being especially distinct at the end of the portage 4 miles northeast of the mouth of Newhalen River and at Millet's camp 3½ miles west of Chekok River. At each of these points several parallel beaches were observed, the highest being about 40 feet above the level of the lake. Similar beaches extending up to an elevation of about 100 feet above the present lake level were seen at a point about 23 miles east of the outlet of the lake.

These terrace deposits and the abandoned beaches are not well developed at the eastern end of the lake, although they were observed in places. A distinct bench is shown on the islands of Kakhonak, Intricate, and Pile Bays, as well as on the scattered islands in other parts of the lake. They are, however, cut benches rather than constructional beaches.

The terrace deposits were observed on the shores of Cook Inlet only at Bruin Bay and Ursus Cove. At the former point the neck of the peninsula projecting from the south shore of Bruin Bay is filled in by a deposit of cross-bedded and locally indurated sand and gravel. The deposit is 80 feet thick at this point, and is well terraced on the west side of the peninsula. Similar deposits occur on the south shore of the bay, west of the island, but were not observed except from a distance.

The valleys tributary to Iliamna Lake on the north side east of Newhalen River, and the valleys tributary to Lake Clark from the east, contain terraced gravel deposits of a somewhat different type and extending high up the mountain sides. (See fig. 3.)

On the east side of Knutson Creek a gravel terrace with smooth top and steep face about 40 feet high was seen. It appears to have been developed by the reworking of originally morainic material. Along the north shore of Knutson Bay there is a gravel terrace about 20 feet above the lake, sloping slightly for one-fourth to one-half mile to the base of Knutson Mountain, where it is perhaps a hundred feet above the lake. Extending westward from Knutson Mountain, this terrace merges into the broad lake-dotted gravel plain north of Chekok Bay. Northward this plain rises by very gentle slopes to an elevation of over 1,200 feet at the base of the mountains. Chekok River, Canyon Creek, and other streams have notched terraces in this deposit, and now occupy rather narrow canyons in the gravels. Canyon Creek, however, is so named because of a canyon, 300 feet deep in one place, which is cut in granite. Along this canyon the gravel mantle is comparatively thin and lies on a gently sloping rock bench.

The minor valleys and gulches in the mountains, 7 miles north of Chekok Bay, have these gravel terraces extending up to a nearly uniform level of about 1,400 feet. Above this height the streams have open mature valleys within the mountains; below it they are intrenched in recent gorges in the gravel plains. The gravels extend westward along the face of these mountains and through the pass between them and Roadhouse Mountain. They also occur on both sides of Tazimina River and Lakes, and continue northward from the foot of Lower Tazimina Lake, through Kokteekish Pass, to merge with those on the south side of Lake Clark.

On the south side of Lower Tazimina Lake the mountain wall lies nearer the shore than on the north side, and is quite steep, so that the gravel terrace is neither wide nor high, but at the southwest end of the lake the gravels run up to about 1,400 feet, forming at least four distinct benches at about 800, 1,000, 1,200, and 1,400 feet above sea level. On the north side of the lake there is a pond-dotted gravel plain about a mile wide, with one distinct bench at about 1,000 feet. From this bench the gravels slope up to the mountains, extend into the valleys, and fill a 1,900-foot pass to the Lake Clark drainage. On the east side of Lake Clark from Kokteekish Pass to Currant Creek and extending up the valley of Tanalian River there are wide gravel deposits bordering the lake and lying up to 600 or 800 feet above the lake. At a few places there are rock outcrops on the beach, so that it seems likely that the gravels lie on a rock bench. These gravels rise from the beach in two or three terraces and are marked by long ridges paralleling the shore, between which lie several elongated ponds.

The valleys entering Lake Clark from the east are gravel-filled up to elevations of 2,000 to 2,400 feet at successively higher levels on the creeks toward the head of the lake.

The lower part of the valley of Kontrashibuna Lake and Tanalian River are flanked by gravel terraces lying as high as 1,000 to 1,100 feet. They are narrow and lower or lacking where the mountain walls descend steeply to the lake.

CONDITIONS OF DEPOSITION.

These terrace deposits were probably derived chiefly, if not almost entirely, from glacial detritus. They were laid down in their present position by water.

The terraces at the lower levels on Iliamna and Clark lakes probably consist chiefly of material deposited near its present position as moraine and reworked by waves. The waters in which the reworking and redeposition were accomplished are believed to have been those of an estuary extending from the present Bristol Bay into the lower ends of the valleys of Iliamna and Clark lakes. The reason for the postulation of an estuary rather than a larger lake follows from the absence of a barrier high enough to hold a lake up to the higher terrace levels. The absence of the terraces and terrace deposits in their complete development at the upper ends of the lakes is ascribed to the presence of large glaciers in these localities during the time of the formation of most of the terraces. The higher elevation of the terraces on Lake Clark may be explained as due to the presence of the large Iliamna Lake glacier across the lower end of the Newhalen Valley after the Lake Clark glacier had retreated well up the lake. The waters in which these were laid down were thus lacustrine rather than estuarine.

The higher terraces in the Chekok, Tazimina, and Kontrashibuna valleys and east of the lower end of Lake Clark, which are shown on figure 3 (p. 89), are regarded as having been deposited in a series of small local marginal lakes in small valleys tributary to the larger valleys which were occupied by the main glaciers. These marginal lakes existed because of ponding by the main ice stream, and were hence local temporary features existing only at favorable times and places.

BEACH AND FLOOD-PLAIN DEPOSITS.

Beaches are well developed on the lower ends of Iliamna and Clark lakes, but are noticeably absent on much of the shores of the upper ends of these lakes, where glacial erosion has been most active and where glacial and terrace deposits are less abundant. The difference in degree of development of the beaches is in part due to the fact that the lower ends of the lakes are older, as the ice retreated from them before it left the upper ends. It is, however, in larger part caused by the presence of abundant unconsolidated deposits at the lower ends of the lakes and of resistant granite at the upper ends and by the fact that the lower ends of the lakes are broader and, in the case of Iliamna Lake, less broken up by islands, so that the waves have broader sweep.

Beaches are not well developed on the coast of Cook Inlet south of Chinitna Bay, apparently because of the youth of the coast and the absence of unconsolidated materials on which the waves could easily work.

Flood-plain deposits are well developed in many of the larger valleys, such as those of Iliamna River, Pile River, Knutson Creek, Chekok River, Tazimina River, Tanalian River, Currant Creek, Chokotonk River, and Tlikakila River. These deposits form the flat alluvial floors, which are particularly broad along their lower portions. They are made up chiefly of coarse gravels, largely of ultimate glacial origin, on the upper parts of their courses and of fine sand and clay near their mouths. Some of them, like Tlikakila

River, Chokotonk River, Currant Creek, and Pile River at their debouchures, have "reentrant deltas," built in fiord heads. Tanalian River has built a delta, Tanalian Point, in Lake Clark. Notable alluvial deposits on Kontrashibuna Lake are the cones and deltas which Kasna, Takoka, and other creeks have built into the lake.

RECENT VOLCANIC DEPOSITS.

Mounts Iliamna, Redoubt, and Augustine (see Pl. VIII, *B*, p. 86) are volcanic peaks which are still to be classed as active. Augustine had a violent eruption[1] in October, 1883, and is still giving off steam. Redoubt had an eruption on January 18, 1902, which sent showers of dust over the country from Lake Clark to the Skwentna Valley, and it is still giving off steam and occasional light showers of dust. Iliamna is not definitely known to have erupted in historic times, and small but fairly persistent clouds of steam are its only signs of life. There are, however, unsubstantiated newspaper accounts[2] of an eruption in 1854.

The entire area of Augustine Island is covered with volcanic detritus, chiefly ash, although some lava is present. The character of the material was determined by Becker[3] as andesitic.

The beach between Tuxedni and Chinitna bays is strewn with numerous fragments of a very fresh vesicular olivine basalt. It is considered highly probable that these fragments were derived from a recent lava stream from Mount Iliamna. On East Glacier Creek and near the base of Mount Iliamna volcanic rocks were seen which were considered as being recent flows from this mountain. One of these is an augite andesite consisting of phenocrysts of basic plagioclase, augite, and magnetite thickly studded in a microcrystalline groundmass of plagioclase and minute magnetites, with probably also some augite. Another specimen from this vicinity is a red porphyritic basalt containing laths of plagioclase, and possibly augite, in an opaque base. Cavities in the rock contain calcite.

STRUCTURE.

INTRODUCTION.

The following pages are intended to include all the available facts bearing on the structure of this region. In many areas the actual structure is not known, but it nevertheless seems desirable to present here the known facts, even if it is not possible to interpret them and to describe systematically the structural relations.

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[1] Davidson, George, Notes on the volcanic eruption of Mount St. Augustin, Alaska, Oct. 6, 1883: Science, vol. 3, 1884, pp. 186–189.

[2] Alaska's great volcano: Evening Star, Washington, D. C., Jan. 22, 1876, p. 7 (reprinted from San Francisco Chronicle).

[3] Becker, G. F., Reconnaissance of the gold fields of southern Alaska, with some notes on the general geology: Eighteenth Ann. Rept. U. S. Geol. Survey, p. 3, 1898, pp. 28–30, 52–54.

It will be noticed that considerable detail is presented in the pages dealing with the Cook Inlet forelands, while there are less definite conclusions and far less detail for the other districts. The reasons for this inequality of detail are that the better known stratigraphic relationships in the former district permit more refined structural observations, while the more complex structure in the rest of the region introduces problems which would be difficult of solution even if there were unaltered sedimentary beds of known sequence upon which detailed structural observations could be made.

The matter presented under this heading must necessarily appear to be a mass of undigested facts. It is admitted to be just that. The reader should, however, remember that it is not intended as a systematic discussion of the structure, but rather as a record of the existing observations, made for the benefit of future observers.

COOK INLET FORELANDS.

GENERAL FEATURES.

The Cook Inlet forelands as a structural district to be discussed in this report may be defined as that portion of the Cook Inlet basin (see pp. 26–27) which lies between the west coast of Cook Inlet and the base of the Chigmit Mountains. The most logical position, structurally, for its western boundary is along the great fault or zone of faulting described below (pp. 96–100), which is at most places the western limit of the areas of Middle and Upper Jurassic sedimentary rocks. This is not, however, the limit of the geographic area discussed under this heading, which for purposes of convenience includes a complete discussion of the structures exposed on each of the bays entering Cook Inlet from the west, except Iliamna Bay, which is regarded as lying wholly within the Chigmit Mountains.

The Cook Inlet forelands are characterized structurally by the presence of bedded sheets of sedimentary and volcanic rocks, which are not metamorphosed and most of which are but gently folded. They are cut by intrusive masses which are in general neither large nor numerous, and which by their intrusion have apparently not appreciably altered the lithologic character or the structure of the adjacent rocks.

LOCAL OBSERVATIONS.

Tuxedni Bay.—The rocks exposed on Tuxedni Bay consist of granites at its head, a belt of volcanic rocks farther east, and a belt of Jurassic sedimentary rocks (Tuxedni, Chinitna, Chisik, and Naknek formations) on the lower part of the bay and on Chisik Island.

The granites include rocks of considerable diversity in composition and may represent several intrusions. If such various masses exist, their relations among themselves have not been determined. The contact of the granite mass with the volcanic rocks east of it is supposed to be one of intrusion, although the relations have not been determined locally.

The volcanic rocks likewise include several types of which the interrelations are not known. They may include successive flows, flows with intrusive masses cutting them, or either or both kinds of rock brought into their present structural arrangement by folding or faulting, or both. The nature of the contact of the volcanic rocks with the western edge of the sedimentary rocks east of them is not known. One of three possible relations exists. The Tuxedni sandstone, which is the lowest and westernmost of these sedimentary formations, may rest conformably or unconformably upon the volcanic rocks, the two may be separated by a fault, or the easternmost member of the volcanic rocks may locally be a dike younger than the Tuxedni sandstone. The fault relationship is believed, for reasons that will appear below (p. 97), to be the most probable.

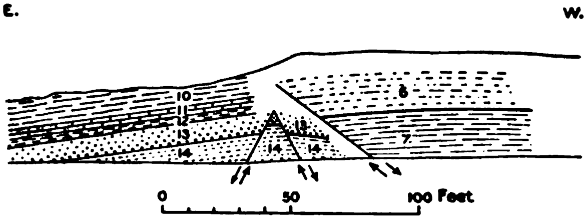

FIGURE 4.—Section showing faults on south shore of Tuxedni Bay, 2 miles west of Chisik Island. The beds in this section are numbered as in the stratigraphic section on pages 60–61.

The several sedimentary formations belong in normal, conformable, stratigraphic sequence one above the other in the order of their areal distribution from west to east. In harmony with this sequence there is a general easterly dip in this part of the bay.

This dip continues without interruption, except possibly between Chisik Island and the point on the mainland west of it, from the westernmost sedimentary outcrop on the western arm of the bay to and somewhat beyond the northern and southern extremities of Chisik Island. There is a western dip on the northern part of the eastern shore of Chisik Island, so the island is, in part at least, synclinal in structure.

Numerous small faults and probably several larger ones were observed on the south shore of the bay. Several of these are shown in figure 4.

Coast between Tuxedni and Chinitna bays.—The shore of Cook Inlet from Tuxedni Bay to Chinitna Bay is mostly a low, sandy beach behind which is a marshy flat. Except at the mouth of

Tuxedni Bay, the hills are a mile or two back from the shore. The easternmost of these hills form a monoclinal ridge parallel to the shore. They consist of the rocks of the Naknek formation, having a dip of from 10° to 30° east.

Chinitna Bay.—The upper end of Chinitna Bay is at or near the western edge of the presumably Lower Jurassic porphyries and tuffs. These rocks form all the outcrops on the western half of the north shore of the bay. The eastern half has magnificent exposures of the Chinitna and Naknek formations. At the entrance on the north shore is a lone outcrop of Tertiary rocks separated from the nearest Jurassic rocks west of it by an interval of sand beach and marsh. The southern shore has outcrops of Tuxedni sandstone near the head of the bay, and of Chinitna shale and Naknek formation near the entrance. Marshy land intervenes between them.

The structural relations of the porphyries and tuffs to the sedimentary rocks east of them could not be directly determined. The fact that westernmost outcrops of sedimentary beds are of the Chinitna shale on the north shore, but of the Tuxedni sandstone on the south shore, and that in each case the concealed interval [1] is not large, suggests that this contact is a fault. This condition is also indicated by the fact that the contact of the Tuxedni sandstone with the porphyries and tuffs has here transgressed eastward in comparison with its position on Iniskin Bay, so that there is on the north shore of Chinitna Bay only one fold between the eastern border of the porphyries and tuffs and the coastal monocline, while on Iniskin Bay (see p. 99) there are several folds in this interval.

The exposures of the Naknek formation at the mouth of the bay are part of the eastward-dipping monoclinal belt which extends parallel to the coast northward to Tuxedni Bay. The dip of the beds of the Naknek formation just within the bay is from 20° to 25°, but flattens going westward until, at a point about 3 miles inside the bay, the Chinitna shale exposed on the north shore is almost horizontal. Observations made at a distance from the outcrops suggested that the dip turns westward just before the contact with the volcanic rocks is reached.

Exposures on the south shore of the bay are lacking between the cliffs at the entrance to the bay and those near its head. Eastward dip was observed at both these points, but conditions farther south indicate that several folds may be present in this concealed interval.

The Tertiary rocks on the north shore of Chinitna Bay near the entrance are horizontal. It may be that the general structure has flattened at this point, and that the underlying Jurassic rocks also are horizontal, or the latter may continue dipping eastward beneath the Tertiary rocks which lie unconformably upon them in the attitude of deposition.

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[1] The concealed interval on the north shore of the bay may contain a narrow belt of the Tuxedni sandstone and is so indicated on the geologic map (Pl. II) and on the structure section in figure 5, page 98.

The structural facts observed on Chinitna Bay are presented graphically in figure 5.

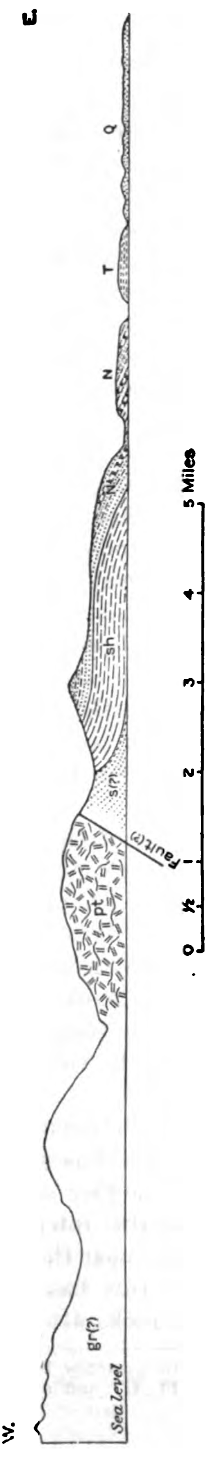
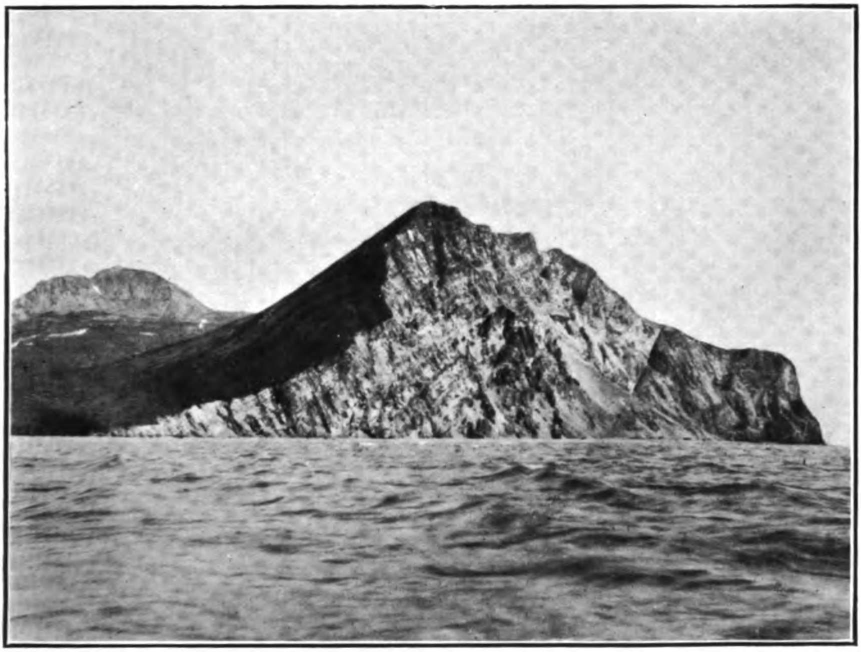


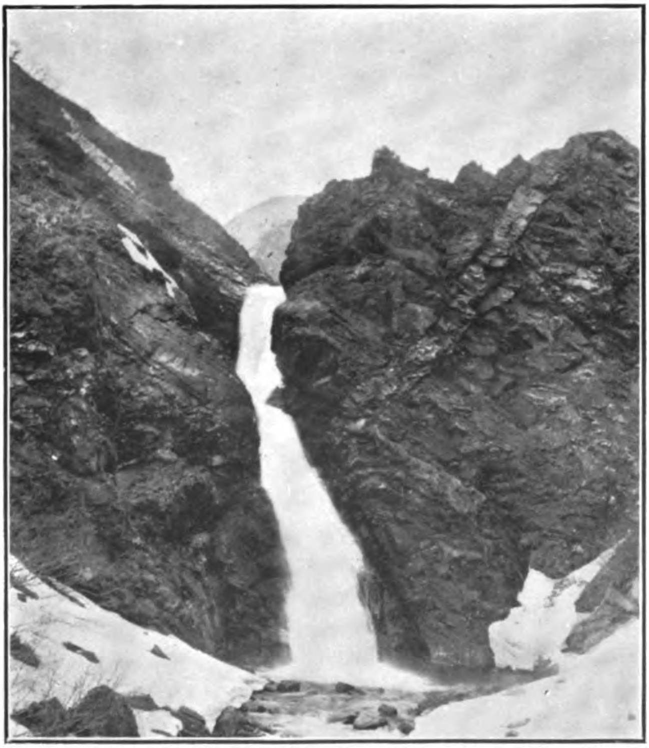
FIGURE 5.—Sketch showing structure on north shore of Chinitna Bay. gr, Granitic rocks (?); pt, porphyries and tuffs; s, Tuxedni sandstone (?); sh, Chinitna shale; N, Naknek formation; T, Tertiary beds; Q, Quaternary deposits.

Coast between Chinitna and Iniskin bays.—The shore of Cook Inlet from Chinitna Bay to Iniskin Bay consists of rocky cliffs giving clean but not very thick sections of the massive rocks of the Naknek formation. A range of hills parallel to the coast and monoclinal in structure lies close to the shore and contains the Naknek formation on its crest and east side, and the Chinitna shale on its western slope. The dip is uniformly eastward as in the already described continuation of this ridge north of Chinitna Bay. The ridge is broken through by drowned valleys at Dry and Oil bays. At the latter point magnificent exposures (Pl. VII, *A*, p. 66) of the rocks of the Naknek, Chisik (?), and Chinitna formations reveal the monoclinal structure of the range as shown in figure 6. The strike parallels the shore throughout the whole length of this belt, and the dip varies from 20° to 45°. The steepest observed dip is about a mile south of Chinitna Bay. The dip flattens eastward from the monoclinal ridge, and on the end of the low point at the entrance to Oil Bay and on the islands between there and Iniskin Bay it is almost horizontal.

Iniskin Bay.—The rocks exposed on Iniskin Bay consist of the presumably Lower Jurassic porphyries and tuffs with intrusive masses on the west and north shores, and of sedimentary Jurassic beds on the east shore. The latter lie in parallel belts consisting successively from north to south of the Tuxedni, Chinitna, Chisik, and Naknek formations. The structural relation of the sedimentary to the older igneous rocks is in part due to faulting, as is shown in figure 7, although at one locality the Tuxedni sandstone was observed to overlie porphyries and tuffs unconformably. (See pp. 58–59.)



A. KAMISHAK CHERT OVERTHRUST ON NAKNEK FORMATION ON NORTH SHORE OF URSUS COVE.



B STEEPLY TILTED SLATES CUT BY DIKE ON CREEK NEAR HEAD OF COTTONWOOD BAY.

The sedimentary formations are flexed into open folds and are cut by faults. The dips are low and gently undulatory for the greater part of the length of the shore. Several folds are present of which the most prominent is the monocline exposed on the lower part of the bay. This is the southern end of the monoclinal block which has been described above as extending down the coast from Tuxedni Bay. The section in figure 7 is believed to represent the structural details exposed on the east shore of the bay.

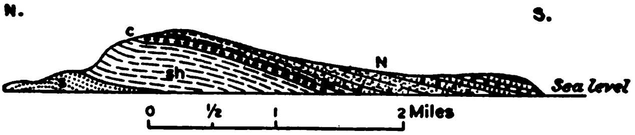


FIGURE 6.—Structure section on east shore of Oil Bay. s, Tuxedni sandstone; sh, Chinitna shale; c, conglomerate; N, Naknek formation.

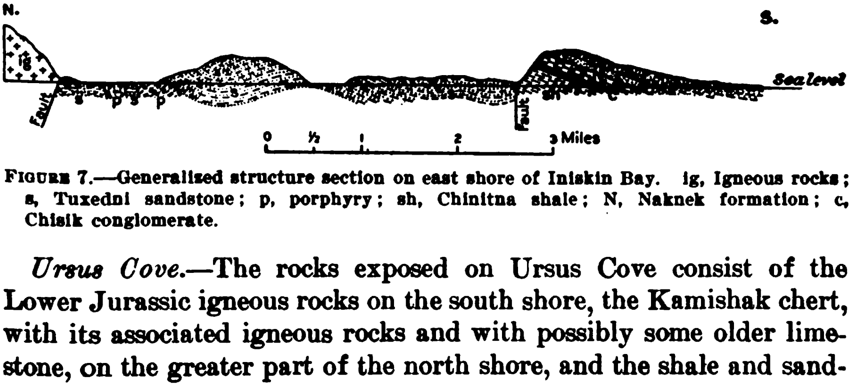


FIGURE 7.—Generalized structure section on east shore of Iniskin Bay. ig, Igneous rocks; s, Tuxedni sandstone; p, porphyry; sh, Chinitna shale; N, Naknek formation; c, Chisik conglomerate.

Ursus Cove.—The rocks exposed on Ursus Cove consist of the Lower Jurassic igneous rocks on the south shore, the Kamishak chert, with its associated igneous rocks and with possibly some older limestone, on the greater part of the north shore, and the shale and sandstone of the Naknek formation on the north shore at the entrance. The structural relationship of the various igneous rocks to each other and to the Kamishak chert is not known. The Kamishak chert is strongly folded and appears to lie in a syncline. In its deformation some minor faulting is known to have occurred, and the weaker beds are in places severely contorted. A beautifully exposed fault (see Pl. *IX*, *A*, p. 98, and fig. 8) at the north entrance to the cove shows the Kamishak chert overthrust upon the Naknek formation, which is locally folded into an overturned syncline with its axial plane dipping west. This fold either dies out northward or is more probably cut off by the eastward transgression

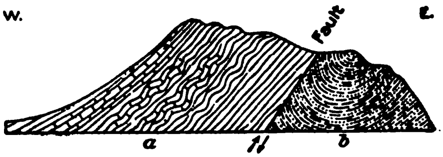


FIGURE 8.—Sketch showing Kamishak chert overthrust upon Naknek formation at mouth of Ursus Cove. *a*, Triassic cherts and limestone; *b*, Naknek shales and sandstones.

of the fault, for where the latter cuts the shore about 2 miles north of Ursus Cove the Naknek formation is almost horizontal.

Coast between Ursus Cove and Bruin Bay.—The fault seen at the north entrance to Ursus Cove cuts the shore of Cook Inlet again just south of Ursus Cove, and there separates the igneous rocks exposed on the south shore of Ursus Cove from the Naknek formation which forms the shore of Cook Inlet almost as far south as Bruin Bay, or for a distance of about 8 miles. The Naknek formation is here practically horizontal, as is shown on Plate VII, *B*, page 66.

Bruin Bay.—The rocks on Bruin Bay consist of the Kamishak and Naknek formations and granitic intrusives. The rocks of the Kamishak formation are closely crumpled (see Pl. V, *A*, p. 40) and cut by numerous small faults. The broader structure of these rocks could not be determined. They are overthrust, by the southern continuation of the fault seen at Ursus Cove, upon the Naknek formation, which here lies horizontal or flexed into very gentle wavy folds, whose dips do not exceed a few degrees. The granitic rocks are intrusive into the Kamishak chert, having been intruded after the latter was folded.

Coast of Kamishak Bay south of Bruin Bay.—The shale and sandstone of the Naknek formation in the cliffs at the entrance to Bruin Bay continue southward in an unbroken series of cliffs for about 5 miles. At this point the great overthrust fault, which has been followed southward, cuts the cliffs and brings up a series of massive or poorly bedded rocks, which may be Triassic sediments, but which look from the water more like fine-grained homogeneous crystallines. These extend southward to the southern end of the cliffs. The succeeding 5 or 6 miles of shore are low and sandy, with no rock outcrops.

The head of Kamishak Bay has horizontal rocks of undetermined age on its west shore and horizontal beds of the Naknek formation on its east shore. The relations of the two were not determined. From this point eastward along the south shore of Kamishak Bay for 10 miles, to the mouth of the first large river, the cliffs all show horizontal beds of the Naknek formation. The structural relations of these to the granites and other rocks south of them in the mountains and east of them on the coast is not known.

CHIGMIT MOUNTAINS.

GENERAL FEATURES.

The structure of the Chigmit Mountains presents great difficulties and can not be fully interpreted from the data now at hand. The problems involved are complex in the extreme and will probably be solved only after the sequence of the rocks and their areal distribution are much more accurately known than at present. Detailed mapping in some of the critical localities will probably be required.

The Chigmit Mountains are structurally an area of profoundly metamorphosed Paleozoic rocks, with which are associated intricately folded and much faulted blocks of slightly metamorphosed early Mesozoic sediments and volcanics, both being cut by enormous masses of plutonic Mesozoic intrusives and the whole faulted on a large scale. The general character of the structure is shown in figure 9.

The limits of the Chigmit Mountains as a structural province should probably be regarded as defined on the east by the great fault or zone of faulting described above (p. 95) as extending parallel to the coast of Cook Inlet from Tuxedni Bay to Bruin Bay between the Upper Triassic chert and Lower Jurassic igneous rocks on one side and the Middle and Upper Jurassic rocks on the other; and as defined on the west by the eastern boundaries of the flat or gently folded Tertiary volcanic rocks of the Iliamna basin.

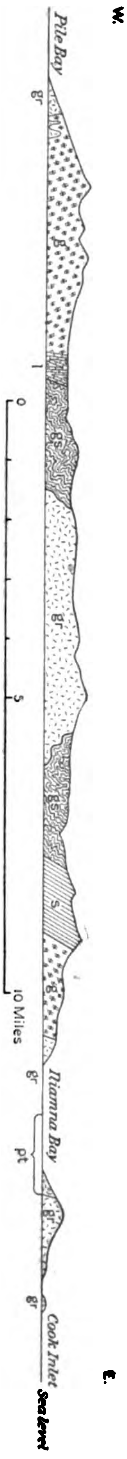


FIGURE 9.—Sketch showing probable structure of the Chigmit Mountains from Iliamna Bay to Pile Bay. gr, Granite; g, greenstone; gs, gneiss and schist; l, limestone; s, slate; pt, porphyries and tuffs.

LOCAL OBSERVATIONS.

Iliamna Bay.—The rocks exposed on Iliamna and Cottonwood bays include probably late Paleozoic slate and greenstone, Upper Triassic sediments, including limestone and the Kamishak chert, volcanic rocks, which probably include both flows and tuffs and which are probably of Lower Jurassic age, Lower or Middle Jurassic granites, and late Jurassic (or younger) porphyry dikes. These, except the last, occur in approximately parallel belts having a northeast-southwest trend. The slate outcrops only at the head of Cottonwood Bay, and the limestone and the Kamishak chert are shown only on Cottonwood Bay and on the south shore of Iliamna Bay, but the belts of other rocks cross the bay, the granite occurring in three such belts. The probable structural relationships are shown in figure 10.

The easternmost of the granite belts crosses the bay at its mouth, forming the headlands on each side of the entrance. It is in contact with the Lower Jurassic (?) porphyries and tuffs on the north shore of the bay, and with limestone on the south shore. Both contacts are believed to be intrusive. The limestone on the south shore of the bay is in contact on its west side with the lower Jurassic (?)

porphyries and tuffs. The nature of the contact and the structural relations are not known. The limestone itself is complexly folded and includes within its general area many small masses of igneous rocks of indeterminate structural relations to it. The Lower Jurassic (?) porphyries and tuffs appear to rest conformably upon the Kamishak chert on the east shore of Cottonwood Bay, and are in contact with a second belt of granite on the north shore of Iliamna Bay. The dips are steeply eastward. The Kamishak chert also has a steep eastward dip. It does not cross the bay, apparently being cut off by the mass of granite which lies west of it and which on the north of the bay is in contact with the porphyries and tuffs. West of this granite is a belt of greenstone, the contact between the two being possibly intrusive, but more likely one of faulting. Granite appears again to the west of the greenstone at the extreme head of Iliamna Bay, the contact appearing to be intrusive. At the head of Cottonwood Bay slate is west of the greenstone. The bedding or cleavage of the slate (Pl. IX, *B*, p. 98) is uniformly northwestward at dominantly high angles, being in general parallel to that of the greenstone. This slate is believed to be older than the greenstone and to be locally overthrust or overfolded upon it.

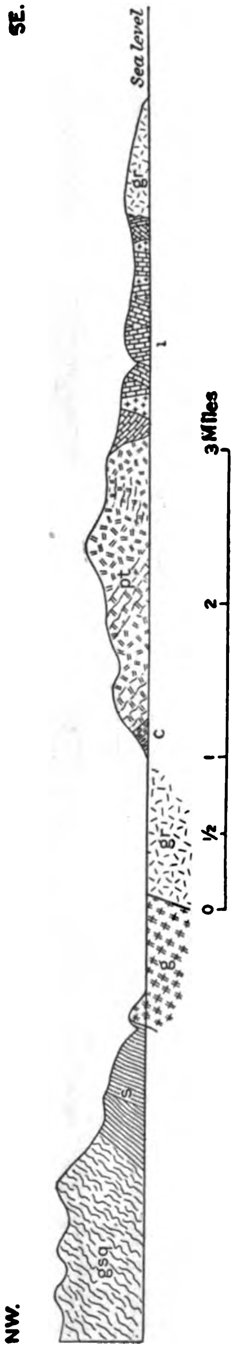


FIGURE 10.—Sketch showing probable structure on south shore of Iliamna Bay. gsq, Gneiss, schist, and quartzite; gr, granite; g, greenstone; s, slate; c, chert; l, limestone with associated igneous rocks; pt, porphyries and tuffs.

Mountains between Iliamna and Pile bays.—The rocks of the mountain area west of Iliamna Bay comprise a group of strongly metamorphosed gneiss, schist, quartzite, and crystalline marble; a group of less metamorphosed and younger rocks including slate, greenstone, and limestone; and one or more intrusive masses of granite. The general interpretation of the structure is shown in figure 9, page 101.

In areal distribution there is a central zone of granite, flanked on both the east and west sides by gneiss with associated schist and quartzite. Within the boundaries of the gneiss and schist are two small areas of crystalline marble. East of the gneiss comes the slate and greenstone of the shores of Iliamna and Cottonwood bays. West of the gneiss is limestone, which is succeeded by greenstone and granite.

The gneiss, schist, and quartzite together constitute a stratigraphic and structural complex which could not be cartographically subdivided in the reconnaissance here described. The crystalline marble occurs within the area of the gneiss either as small lenses or, more probably, as small detached areas of undetermined structural and stratigraphic relations. The quartzite and mica schist also are intimately associated with the gneiss, but probably represent a younger formation at present not separable from the gneiss. The gneiss, schist, quartzite, and marble together have general northeast strike and steep northwest dip. They are probably overthrust or overfolded upon the slate and greenstone at the heads of Iliamna and Cottonwood bays.

A belt of much folded and shattered but otherwise not much altered limestone adjoins the gneiss and schist on the west. This limestone is believed to overlie the gneiss unconformably. The structure of the limestone is shown diagrammatically by figure 11. Associated with the limestone are masses of chloritic schist. These are believed to be part of an older formation folded or faulted in with the limestone but not separated from it in mapping. Their exact stratigraphic and structural relations to the limestone could not be determined.

A large mass of greenstone lies west of the limestone. The structural relations between the two could not be definitely determined. Basic rocks of the same general type as the greenstone and lying along its eastern margin are known to be intrusive into the limestone. The point in doubt is whether these rocks are an integral part of the main greenstone mass, or are later intrusive rocks. West of the greenstone is granite which is clearly intrusive into it.

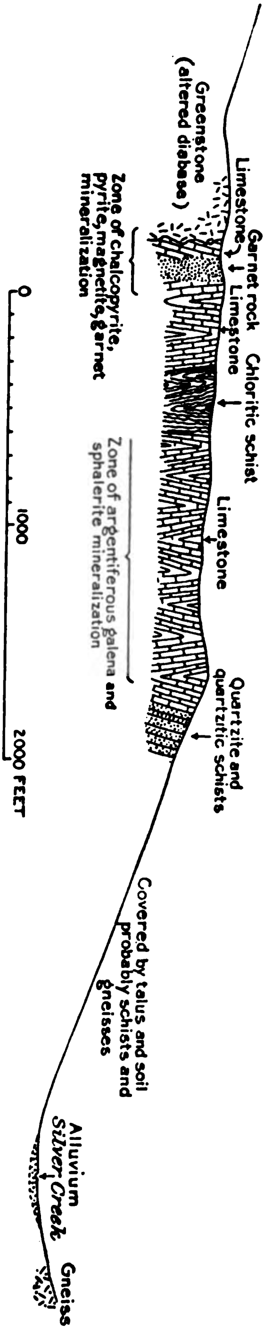

Greenstone (altered diabase)
Limestone
Garnet rock
Limestone
Chloritic schist
Zone of chalcopyrite, pyrite, magnetite, garnet mineralization
Zone of argentiferous galena and sphalerite mineralization
Limestone
Quartzite and quartzitic schists
Covered by talus and soil probably schists and gneisses
Alluvium
Silver Creek
Gneiss
0
1000
2000 FEET

FIGURE 11.—Structure section showing type of folding of the limestone north of Meadow Lake.

Pile Bay.—The exposures on the shore of Pile Bay are all of granite, except for an interval of about 3 miles on the east shore and at the cape on the south side of the entrance to the bay, where there is greenstone.

The contact of granite and greenstone at a point 4½ miles below Iliamna River is clearly one of intrusion. The granite has sent anastomosing dikes into the greenstone, as is shown in figure 9, p. 101, and also in figure 12, and blocks of the greenstone occur as inclusions in the granite. The other contacts of granite and greenstone were not observed, and may be either intrusive or faults. This greenstone mass has general northeast strike and steep dip, and is closely folded, the folding having affected both the bedding and some of the quartz veins.

The exposures of greenstone at the mouth of the bay are less conclusive regarding the relationships, but it is believed that the greenstone is overlain unconformably by porphyries and tuffs and that the two are separated from the granite by a fault. This interpretation is expressed graphically in figure 12. The position of this probable fault should be regarded as the local western boundary of the Chigmit Mountains as a structural province.

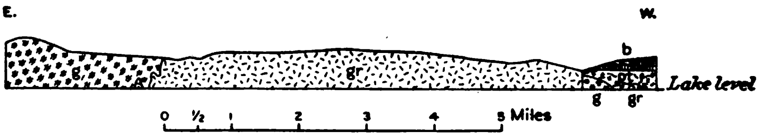


FIGURE 12.—Section showing probable structure on southeast shore of Pile Bay. gr, Granite; g, greenstone; pt, latitic porphyries and tuffs; b, basaltic lavas.

Chekok and Tazimina valleys and neighboring districts.—East of Chekok River and of the foot of Upper Tazimina Lake the known rocks are all granites. Over most of the area west of this are Lower Jurassic (?) porphyries and tuffs, with the exception of two small areas, one 10 miles north of Chekok Bay and the other south of the foot of Lake Clark, in which there are late Paleozoic slates and cherts. These rocks may occur also in other undetected areas. The relation of the granite to the porphyries and tuffs is unknown, but the granite is presumably intrusive into the porphyries and tuffs, as it is on Iliamna Bay. The present contact may, however, be either an intrusive or a fault contact or, in places, may be both. Except on Chekok Bay, where they are within a few hundred feet of one another, these rocks were seen only at the distances of a mile or more from each other. The probable positions of their contacts are believed to be largely in alluvial areas. The porphyries and tuffs, where structure was discernible, as on the mountain 8 miles north of the mouth of Chekok River and in the mountains 5 miles south of Tanalian Point, constitute a series of interbedded flows and pyroclastics, which are moderately flexed, being nearly horizontal at the first locality and dipping 25° N. 35° E. at the second locality. North of the foot of Lower Tazimina Lake the tuff beds are slightly undulatory, but in a broad way appear to be horizontal. The slates, which show only poorly developed cleavage, and the cherts associated with them have been crumpled and tilted at high angles. The strikes recorded are N. 10° E. (magnetic), dip 80° SE., and N. 30° E. (magnetic), dip 90° in the area north of Chekok Bay and N. 70° E. (magnetic), dip 90°, on the hill east of the foot of Lake Clark. The slates and cherts are either unconformably overlain by the porphyries and tuffs, and exposed by the erosion of the latter, or are faulted against them. The former relationship is believed to be the more probable and is expressed in the hypothetical structure section on figure 13.

Kontrashibuna Valley.—The upper part of Kontrashibuna Valley is believed to lie within the area of the granite. Across the central part of the lake is a belt of crystalline limestone and calcareous schist. West of the limestone on the north side of Kontrashibuna Lake are schistose, quartzitic, and slaty rocks. On the south side of the lower half of the lake, and west of the limestone are Lower Jurassic (?) porphyries and tuffs surrounding a small area of late Paleozoic (?) slates and cherts which strike N. 10° E. (magnetic) and dip 80° SE. The relation of these slates to the surrounding porphyries and tuffs is not known. At and below the falls of Tanalian River there is granite. The structural relations of these formations within the Kontrashibuna Valley are supposed to be in general the same as in the neighboring districts to the north and south. The probable structure is indicated in figure 14, page 106; also in figure 17, page 108.

Upper end of Lake Clark.—The rocks of the mountains bordering the upper end of Lake Clark are all igneous or metamorphic. They occur in rudely parallel belts trending approximately north and south. The following structural observations are presented in the order of the geographic position of the localities at which the observations were made, from northeast to southwest. The rock at the head of Lake Clark, and for at least 6 miles up the valley of Chokotonk River, is granite. This granite mass is considered as being a

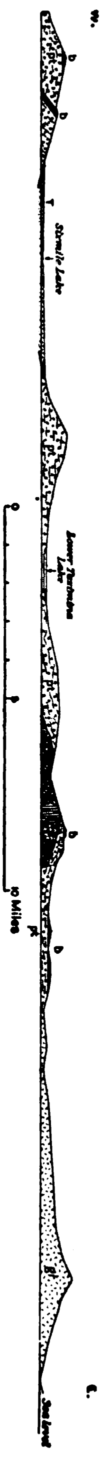


FIGURE 13.—Hypothetical structure section from mountains east of Chekok Valley to hills west of Sixmile Lake. T, Terrace gravels; b, basalt; s, slate; gr, granite; pt, porphyries and tuffs.

great batholith which has invaded the sedimentary beds. It shows foliation in an apparent arch structure centering about a mile below the head of the lake on the west shore. West of this granite is an area of slates and cherts. The contact is concealed on the east shore of the lake, but is well exposed on the west side of the lake, where the granite shows a thick marginal facies of coarse granite porphyry in contact with a zone of rock having a somewhat gneissic appearance, which is the altered and invaded part of the slates and cherts. The slaty rocks have a uniformly northwest strike (N. 46° W., magnetic), and steep southwest dip (70°–73° SW.). They are cut by numerous faults, having planes lying at about right angles to the bedding, on none of which could the amount or direction of movement be determined.

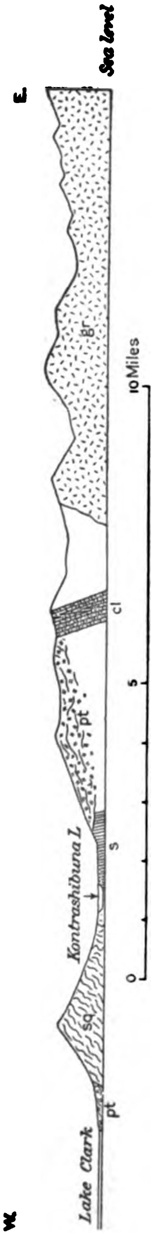


FIGURE 14.—Hypothetical structure section in Kontrashibuna Valley. pt, Porphyries and tuffs; sq, schist and quartzite; cl, crystalline limestone; gr, probably granite; s, slate.

The rocks lying west of the slates and cherts on the west shore of the lake are the tuffaceous beds described on page 55. The attitude of these beds and their relation to the slates was not determined.

These tuffaceous rocks do not cross the lake, their relative position on the east shore of the lake being occupied by a large mass of granite upon which the slates and cherts are overthrust, as is shown on figure 15. The latter beds have steep or vertical dips and rest directly upon coarse granite. The contact is well exposed where it cuts the beach and clearly establishes the fault relationship. At this point the two rock masses are separated by a 4-foot zone of soft, much crushed, and weathered material, consisting of the disintegration products of the slaty rocks above and of the granite below. About midway of this zone the contact surface between the disintegration products of the two kinds of rocks shows sharp and smooth. This surface strikes N. 10° W. (magnetic) and dips 59° NE. No sign of alteration was seen in either rock, except crushing and weathering. The weathered granite is of coarse grain to the very contact.

Areas of somewhat altered igneous rock probably to be classed as greenstone (p. 39) were seen on the east shore of the lake a short distance west of the granite mass just described, and on the west side of the lake west of the Tlikakila Valley. The structural relationship of this rock to the granite is not known.

An area of metamorphic rocks, consisting of a central mass of mica schist and quartzite flanked on either side by calcareous schist and limestone, is exposed on the west shore of the lake just below the area of greenstone. Anticlinal structure is inferred, as is shown in figure 15, because the calcareous rocks appear to dip away on either side from the quartzite schists, although a fan-shaped syncline or one of several fault relationships is possible.

Crystalline limestone, calcareous schist, and quartzite outcrop on the east shore of the lake from about 1 mile above to 7 miles below Currant Creek. The limestone, which is the easternmost and presumably the uppermost of these rocks (fig. 17, p. 108), extends southward without interruption to the limestone locality on Kontrashibuna Lake (p. 105). It is believed also to be the same structural belt as that noted above on the west shore of Lake Clark.

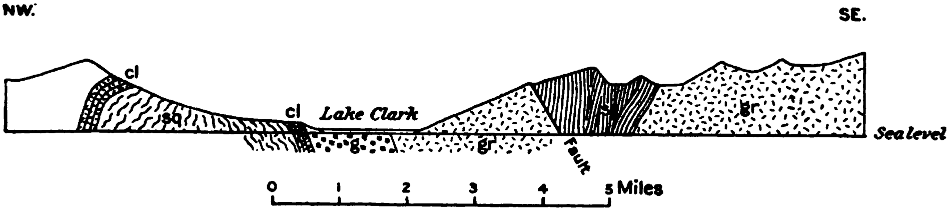


FIGURE 15.—Structure section across Lake Clark below mouth of Tlikakila River. sq, Mica schist and quartzite; cl, crystalline limestone; gr, granite; g, greenstone; s, slate.

These schistose rocks are apparently everywhere closely and intricately folded, minute plication being noted in many of the beds. In general the axial planes of the folds as well as the bedding stand vertical. The closely appressed, nearly isoclinal folds in the calcareous schist on the island 2 miles northwest of Currant Creek are shown in figure 16. The strong internal deformation of these rocks is evidenced by their crystallinity, especially of the limestones, and by the well-developed schistosity of the other beds. These rocks were invaded by small dikes prior to the folding and by granitic intrusives after the folding.

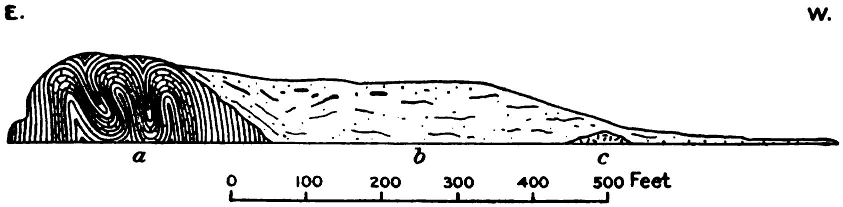


FIGURE 16.—Diagrammatic sketch showing folding of calcareous schist on island 2 miles northwest of Currant Creek, Lake Clark. a, Interlaminated thin limestones, sheared argillites and quartzites; b, soil; c, gabbro.

The contact of the poryphyries and tuffs with the schist east of them is not exposed on the lake shore, and the structural relations are not known. The porphyries and tuffs are continuous with those of the Tazimina Valley. Near their eastern boundary on Lake Clark there are some small detached areas of granitic rocks which are probably intrusive into them. The summit of the hill on the south shore of the lake above Tanalian Point is of basalt provisionally correlated with the Tertiary basalts of the Iliamna Basin and hence supposedly unconformably overlying the porphyries and tuffs, as is indicated on figure 17.

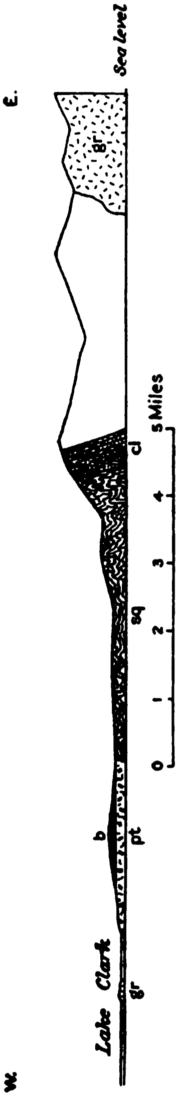


FIGURE 17.—Sketch showing probable structure of mountains east of Lake Clark, 5 miles south of Current Creek. gr, Granite; pt, porphyries and tuffs; sq, schist and quartzite; cl, crystalline limestone; b, basalt.

ILIAMNA BASIN.

GENERAL FEATURES.

The Iliamna Basin as a structural province includes the essentially nonmountainous part of the area drained by the tributaries of Iliamna Lake. It is dominantly an area of bedded volcanic flows and tuffs of Tertiary age, which have been folded to a comparatively small degree. Older sedimentary and volcanic rocks of complex structure are present only along the rather indefinite eastern boundary of the province and at two other restricted areas on the south shore of Iliamna Lake.

LOCAL OBSERVATIONS.

Along the south shore of Iliamna Lake, from a point 15 miles below the head of Pile Bay to a point 12 miles farther west, the Tertiary basalts and tuffs cap the hilltops, resting unconformably upon older igneous rocks, and dipping westward at about 140 feet to the mile. These facts are shown diagrammatically in figures 12 and 18. The eastern termination of these volcanic rocks is at a contact with granite and greenstone and this point should probably be accepted as the local boundary between the Iliamna Basin and the Chigmit Mountains as structural provinces.

The westward dip of the Tertiary volcanic rocks brings them down to lake level at a point about 20 miles below the mouth of Iliamna River. The shores and islands of Intricate Bay are made up entirely of these rocks which here are in general flat, although a few islands show gentle monoclinal structures.

The shores and islands of Kakhonak Bay are likewise made of these same rocks in horizontal attitude, except at the east end of the bay, where the Tertiary lava sheets are folded and where the older volcanic rocks are also exposed.

Tertiary lavas with prevailingly gentle dips make up the south shore of the lake from near the head of Kakhonak Bay to a point 25 miles east of the outlet of the lake, except for one short interval, where the older volcanic rocks are exposed. At the point 25 miles east of the outlet of the lake a fault cuts the shore, separating gently dipping Tertiary volcanic rocks on the east from steeply dipping older volcanic rocks on the west. The latter are overlain unconformably at an elevation of several hundred feet above lake level by gently dipping Tertiary lavas.

All the exposures on the north shore of the lake from a point 3 miles west of Chekok River to 8 miles west of Newhalen River are Tertiary volcanic beds, which are in places horizontal and in places steeply inclined.

The hills west of Roadhouse Portage in the Newhalen Valley are capped by horizontal Tertiary basalts, resting on tuffaceous beds whose structure was not determined. Similar conditions exist in the hills west of Sixmile Lake (fig. 13, p. 105), where there are also basaltic ridges along the eastern face of the hill which may be either inclined intrusive masses or folded sheets.

The exposures on the lower part of Lake Clark are of volcanic rocks, at least part of which are the Tertiary basalts. The character of the exposures is not such that any structural details have been made out.

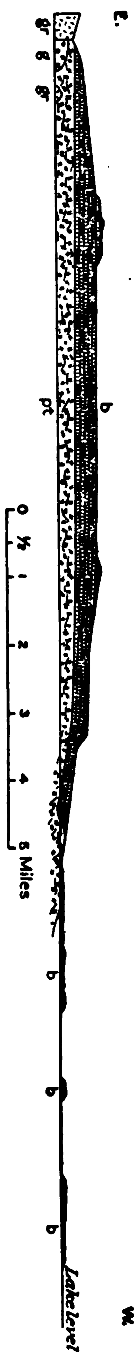


FIGURE 18.—Structure section on south shore of Iliamna Lake from Pile Bay to mouth of Intricate Bay. gr, Granite; g, greenstone; pt, latitic porphyries and tuffs; b, basaltic lavas.

BERING SEA COASTAL PLAIN.

The Bering Sea coastal plain as a geologic province is characterized by the absence, at the surface, of all consolidated rocks, so that its structure is of the simplest kind. The beds of which it is composed are exclusively unconsolidated Quaternary deposits, all of which are believed to lie in nearly or quite their original attitude of deposition. They have been uplifted several hundred feet since their deposition, and this uplift may have been accompanied by tilting or by gentle folding, but of this there is no proof.

HISTORICAL GEOLOGY.

The oldest records of geologic history in this region are believed to be found in the gneisses exposed in the heart of the Chigmit Mountains west of Iliamna Bay. Next in intensity of the metamorphism which they have undergone, and therefore presumably also next in age, are the schists and quartzites which are associated with the gneisses, and the quartzitic and calcareous schists and crystalline limestone of Lake Clark.

There is every reason to believe that all of these rocks were formed and suffered at least part of their deformation during Paleozoic time. It is highly probable that all of them, except the limestones, originated as clastic sediments, and that the gneisses are older than the schists, and owe their coarser grain to more intense metamorphism, or to a greater number of periods of metamorphism. In the latter case the gneisses must have been partly metamorphosed prior to the deposition of the sediments from which the schists were made. The clastic origin of the gneisses is not, however, clearly established. They are granitoid in texture, and may be granitic in origin. They may consequently have had their origin from the deformation of granite rocks intruded into the now schistose sediments.

The slates of the mountains west of Cottonwood Bay, and the slates and cherts of the Lake Clark valley were derived from fine-grained clastic sediments deposited after the schists were metamorphosed. Their date of deposition was in Paleozoic time, probably toward its end. They probably underwent part of their metamorphism during the Paleozoic.

The rocks described as greenstones were derived by alteration from basic igneous rocks, which were at least partly extrusive, and seem to include some waterlaid deposits, and possibly also some rocks originally intrusive. The extrusive and bedded rocks were probably laid down in late Paleozoic time, probably not long after the deposition of the beds now appearing as slates. Their metamorphism, and possibly part of their deposition, may have occurred in the early Triassic. There is no evidence as to the age of such of these rocks as may be intrusive.

From the foregoing it is seen that the record of Paleozoic history in the region is very incomplete. Four periods of subaqueous deposition are recognizable, but the establishment of the first of these is doubtful, and it may be that the rocks referred to it were formed by intrusion after the close of the second (as outlined above) period of sedimentation. The last and closing Paleozoic period of rock making in this region was one of volcanicity. Each of these periods was followed by periods of deformation and metamorphism, or, in other words, by orogenic movements. The erosion cycles which these early movements determined, and the ultimate effect of these movements upon the present physiography of the region, can be only conjectured.

The stratigraphic record begins to be more complete in Upper Triassic time when a great thickness of limestone followed by shaly and cherty beds was laid down. These rocks were intruded by basic masses and were intensely folded near the beginning of Jurassic time. Volcanic outbursts, in early Jurassic time, covered much of this region with lavas and tuffs. There is no local evidence that oceanic waters covered any part of this area while this was going on, but the similar and probably contemporaneous Lower Jurassic volcanic beds on the east coast of Cook Inlet were, in part at least, laid down in marine waters.

At some period after the end of Triassic time and after the folding of the Triassic beds, and probably near the end of the Lower Jurassic, the great granitic masses of the Chigmit Mountains were intruded.

In Middle Jurassic time the present Cook Inlet region became the site of marine sedimentation, and the Tuxedni and Chinitna formations were deposited. If these conditions extended into the present position of Iliamna and Clark lakes, subsequent sedimentation has buried or subsequent erosion has removed the sediments. The waters in which these beds were laid down are known to have extended north along the present site of the Alaska Range and east into what is now the Matanuska Valley.

At the beginning of Upper Jurassic time erosion had probably proceeded far enough in the present Chigmit Mountain area to unroof the granites and furnish detritus from them to the waters in which the Chisik conglomerate was laid down. The deposition of this coarse material was apparently restricted to small areas.

The deposition of the Naknek formation was in a sea of broad extent which apparently reached westward along the present Pacific coast as far as Chignik, and eastward into the present Matanuska and Chitina valleys. The waters were probably shut off from the present area of the Chigmit and Alaska ranges and from the country north and west of them. These areas were probably a region of uplift and vigorous erosion which furnished the fresh detritus which makes up the great thickness of the Naknek sediments. Volcanic agencies were apparently active from time to time along the coast, since many beds of the Naknek formation are tuffaceous and others appear to be lava flows.

The absence of Cretaceous beds within this region indicates land conditions during Cretaceous time, although the possibility of the deposition and subsequent erosion of beds of that age can not be denied.

The area described above as the Iliamna Basin was probably lowered by structural depression or by vigorous erosion during the late Mesozoic and early Tertiary. In Eocene or Miocene time it received large quantities of volcanic detritus from unknown sources and was largely filled with basaltic lavas and tuffs. These beds were subsequently gently folded, and in them were eroded the present lake valleys. These were afterward occupied by large glaciers which doubtless contributed a great share toward the deepening and broadening of the valleys into their present form. On the retreat of the glacial ice the valleys were occupied up to a height of about 150 feet above the present sea level by estuarine waters by which broad terraces were built. The present lakes have been little modified since the uplift which terminated this estuarine occupation.

The Cook Inlet basin probably originated as a down-folded or down-faulted area in a broad sheet of Mesozoic sediments, sometime after the close of the Jurassic. The immense thickness of the Jurassic deposits suggests that important movements along the position of the present west shore of the Cook Inlet were in progress during the deposition of these beds. These movements probably continued during much of the Cretaceous. By Tertiary time the depression had been somewhat enlarged by erosion of part of the Mesozoic rocks and by the uplift of the granitic and other crystalline areas on the margins. It was then partly filled with Eocene or Oligocene fresh-water sediments. These were afterward slightly folded and uplifted and the present water-filled depression was cut in them. This was then invaded by glaciers and on their retreat was overfilled with ocean or brackish water in which were deposited the gravels which now cover the terraces.

The volcanic activity now in evidence at the volcanic peaks of Augustine, Iliamna, and Redoubt is probably but the local survival of activities which began at least as far back as the early Mesozoic and has continued intermittently until now. The periods of greatest volcanic activity were the late Paleozoic or early Triassic, the early Jurassic and late Tertiary.

The more or less approximate accordance of mountain summits (Pl. VIII, *A*, p. 86) throughout much of the region, as well as the presence of fairly mature open valleys (p. 85) above the limit of general glaciation, suggest that there was a period, prior to the more widespread glacial occupation, in which the land surface was reduced to considerably less relief than it now possesses. The evidence at hand is not precise enough to warrant the conclusion that this old surface was a peneplain whose present broader differences of relief are due to warping. The existing features are capable of many possible explanations, none of which can now be positively demonstrated. The detailed interpretation of the physiographic history of this region will accordingly be left for future study.

MINERAL RESOURCES.

GENERAL STATEMENT.

The prospective mineral resources of the Iliamna region are copper, silver, gold, and petroleum. For about a decade prospectors have been attracted to this and adjoining regions in search for copper lodes, gold placers, and oil fields. The first discoveries seem to have been the petroleum seepages at Oil Bay (see p. 127), and later the Dutton copper lodes were located. The attempts to develop these fields brought to the region men who have made a number of other mineral locations.

There has been no production of mineral wealth in the region save for a few dollars won from the gold placer prospects and less than a ton of copper ore shipped out for a smelter test. The present development warrants no statement as to the future of the region.

The descriptions which follow are necessarily not exhaustive. The time available for examination of the properties was too short for detailed study, and, furthermore, none of the prospects had been developed to an extent which would have assisted appreciably a detailed investigation. Inasmuch as the unequal development of the several claims and the varying amount of time spent in examining them bear no relation to the importance of the claims, the space devoted to the discussion of the various properties is to be taken as an index not of their relative importance but merely of the extent of information obtained about them. It should be stated that it is impossible in work of this kind to attempt to collect samples for assays. Consequently, where values are stated in the following pages, they are as reported by the owners of the claims.

GEOGRAPHIC DISTRIBUTION.

With the exception of the oil seepages in the foothills bordering Cook Inlet and one prospect on the southern shore of lower Iliamna Lake, all the prospects so far located in this region are in the Chigmit Mountains. As has been pointed out (see p. 27), this is the area of oldest rocks of the region and the area of the great granitic intrusions.

The prospects are in three areas—between Iliamna Bay and Pile Bay; on the north shore of Iliamna Lake; and on Kontrashibuna

Lake. To some extent this distribution is governed by the geographic distribution of the limestones and by the established routes of travel.

GEOLOGIC OCCURRENCE.

Under this heading the possible economic features of the several geologic formations of this region are discussed. The areal distribution, lithologic character, stratigraphic relations, and structure of these formations are described in the preceding pages. The table opposite page 31, and the geologic map (Pl. II) summarize most of the more important geologic information.

The Paleozoic gneisses, schists, and marbles are known to be mineralized at one locality, about 1½ miles west of the head of Iliamna Bay. Here the mineralization is by contact metamorphism of one or more small detached marble masses. At this place hornblende granite is the immediately adjacent rock and greenstone is near by. Elsewhere in the region these Paleozoic formations are of interest because they occur in close association with the limestones described below, which are mineralized. In the Lake Clark region quartzitic schists lie west of the limestone belt. South of Iliamna village, the schists and gneisses limit the limestone belt on the east.

On the Paleozoic and Triassic limestones (pp. 32–35, 41–47) are located four important prospects. Copper deposits have been discovered on each of the areas of limestones recognized in the geologic mapping and on one of them there is also a silver-bearing galena-sphalerite lode. Two of these copper deposits appear to be of contact-metamorphic origin. The one south of Iliamna village is at the contact of greenstone or altered diabase or diorite, and the one on Kontrashibuna Lake is probably near the contact with granite or diorite. The copper deposit at Millet's is near the contact of a basaltic rock with limestone, but this association has not here been shown to be of significance with respect to the mineralization. The silver-bearing lode is in the limestone paralleling the contact-metamorphic copper lode south of Iliamna village. At this locality the important rocks areally associated with the limestone are andesitic porphyry dikes of unknown age.

The greenstones (pp. 38–41), which are metamorphosed basic igneous rocks, are of economic importance for two reasons—first, because within them quartz veins carrying chalcopyrite and pyrite have been discovered; and secondly, because a copper lode has been located along their contact with the limestone south of Iliamna village.

The Kamishak chert (pp. 47–50) is not known to contain or to be associated with mineral deposits of economic interest.

The porphyries and tuffs (pp. 50–59) have been noted in several places to contain quartz veins with pyrite, or to be impregnated with pyrite along fracture zones. One of the latter occurrences has been located as a mineral claim (p. 125).

The granite, quartz diorite, etc. (pp. 74–77), which occupy most of the high mountain area may, at one locality, near the head of Iliamna Bay, and possibly at another, near Kontrashibuna Lake, be the intrusives to which are due the contact-metamorphic developments at the copper lodes. This formation has further interest to the prospector because in it on Iliamna Bay a pyritiferous fracture zone, rumored to contain a little gold, has been found, and, furthermore, because there are copper-bearing quartz veins in it near Knutson Bay on Iliamna Lake.

Small porphyry dikes were seen on Iliamna and Cottonwood bays, at many points on Iliamna Lake, and at the southern end of Lake Clark. They cut the greenstone, granite, and the porphyries and tuffs. At nearly every dike which was studied the country rock is impregnated with pyrite. So constant is this association that the presence of finely disseminated pyrite was regarded in the field as a reliable indication of a near-by dike, which in most places was actually found. It is not known that any of the pyritiferous zones of this class carry valuable minerals, but, nevertheless, these dikes have evidently contributed toward the mineralization of the region, and they may yet prove to be of importance as a guide to the discovery of valuable deposits.

The unaltered Mesozoic formations of Cook Inlet (Tuxedni sandstone, Chinitna shale, Chisik conglomerate, and Naknek formation), described on pages 59–74, can not be expected to contain ore deposits. They are, however, the locus of the oil seepages described on pages 126–130, which some years ago attracted a good deal of attention.

The Tertiary sediments, which in adjoining regions of Alaska contain important coal and lignite beds, are very meagerly developed in this region (pp. 77–82), and are without coal. The Tertiary here consists chiefly of basaltic volcanics, which so far as known are devoid of mineral wealth.

The Quaternary sands and gravels have on a few streams yielded sufficient placer gold to incite a few men to further search (p. 126).

Broadly speaking, it may be said that three rather definite loci of mineralization have been found in this region—limestones at or near the contact of igneous rocks; greenstones, in which there are mineralized quartz veins; and granite or granodiorite, in which there are mineralized quartz veins and also pyritized fracture zones. Pyritized fracture zones, some of which are also quartz healed, occur in various other rocks, chiefly in the volcanic rocks.

The most promising of the present locations are those in the limestones. Though generalization regarding ore occurrence in this region is hardly warranted by what is known of the few prospects so far located, yet it is perhaps indicated that the limestone belts, and especially the contacts of the limestones with the greenstones and the granites and granodiorites, will be the more fruitful fields for prospecting. The larger of the known copper deposits and the silver-bearing lead and zinc lode are restricted to the limestones. These limestones, it should be noted, have not a very wide distribution, but they have not been prospected throughout their known extent. It seems probable, from such data as are at hand, that some of the mineralization of the limestones is genetically related to the intrusion of igneous rocks, at some places of granites or granodiorites, at another of diorite or diabase altered to greenstone, and at another place perhaps of andesitic porphyries.

One of the purposes of this paper is to furnish the knowledge of this region thus far gained which may serve as a guide to further prospecting and development of its mineral resources. The geologic formations above enumerated have been separately delineated on the map and their areal and structural relations are discussed in preceding sections of this report. In using this report, however, it must be recognized that the work upon which it is based was a reconnaissance, and that therefore the mapping and the discussion are in many instances generalizations or are inferential. For the most part the extent and distribution of the several formations are probably well indicated, so that the prospector may pick out the areas of those formations which he deems worthy of further investigation because of what has been heretofore learned of them.

DESCRIPTION OF MINERAL DEPOSITS.

COPPER.

OCCURRENCE OF THE ORES.

The copper deposits of this region may be referred to two classes: (1) Chalcopyrite deposits in limestone—(*a*) associated with minerals of contact-metamorphic origin, and (*b*) without evidence of contact-metamorphic origin. (2) Chalcopyrite in quartz veins in greenstone and in granite.

Only the deposits in the limestone have as yet developed any prospective value. These are known at four localities—2 miles west of the head of Iliamna Bay; 9½ miles west-northwest of the head of Cottonwood Bay; on Kasna Creek near Kontrashibuna Lake; and at Millet's, on Iliamna Lake, 22 miles west of Iliamna village. At each of these localities the mineralization is in limestone near its contact with an igneous formation. At the last-mentioned place the contact is not exposed and there is no evidence as to its nature. At the other localities there are diorites or diabases intrusive into the limestone. The limestones are metamorphosed by coarse recrystallization of the calcite and the development of garnet, epidote, magnetite, hematite, and quartz, besides the sulphides, pyrite, and chalcopyrite. These developments in general are close to and parallel with the igneous contacts, but from place to place along these contacts they vary considerably in mineral association, in shape, and in size. They are irregular and nonpersistent. In all their features, their geologic position, mineralogy, and outline they have the characteristics of contact-metamorphic deposits.

COPPER MINERALS.

There are only three copper minerals known from this region. Of these chalcopyrite alone is important; the others, malachite and azurite, are scanty in amount and are products of weathering of the chalcopyrite. Some of the iron pyrites associated with the chalcopyrite is cupriferous.

Chalcopyrite.—Throughout the region chalcopyrite ($CuFeS_2$, 34.6 per cent copper) is the ore mineral of the copper prospects.

It is found in limestone accompanied by pyrite, calcite, and quartz. In some limestones that have been affected by contact metamorphism, quartz, epidote, chlorite, pyrite, and calcite, or epidote, calcite, hematite, quartz, and pyrite accompany the chalcopyrite. Here the association with the calcite or part of the calcite, quartz, and pyrite seems to be always more intimate than with the other minerals. In one place in limestone chalcopyrite is associated with garnet, epidote, calcite, and magnetite.

At other localities chalcopyrite is found in veins of quartz cutting granites and greenstones. Two such veins have been reported to carry gold. The only other (primary) mineral in the veins, so far as known, is pyrite.

Malachite.—The green copper carbonate ($Cu_2(OH)_2CO_3$, 57.5 per cent copper) forms thin crusts on the ores and is a very prevalent stain on the copper minerals and country rock, not only at the prospects, but also where quantities of copper sulphides too small to attract notice of themselves are present, as in the greenstone bluff just west of the mouth of Tlikakila River.

Azurite.—The blue copper carbonate ($Cu_3(OH)_2(CO_3)_2$, 55.3 per cent copper) is not commonly found in this region. It was noted as a thin coating on the sulphide ores at Kasna Creek and at Millet's, and in the quartz veins on the prospect 2½ miles below the mouth of Iliamna River.

DESCRIPTIONS OF CLAIMS.

Dutton prospects.—The claims of the Dutton Mining & Development Co. are about 9¾ miles west-northwest from the head of Cottonwood Bay and about 6 miles south-southwest of Iliamna village. (See fig. 19.) The prospect is reached from Cottonwood Bay by a good trail, 14 miles long, on easy grade. Part of this (about 9 miles) has been made into a wagon road. There is also a steeper 6-mile trail from Iliamna village.

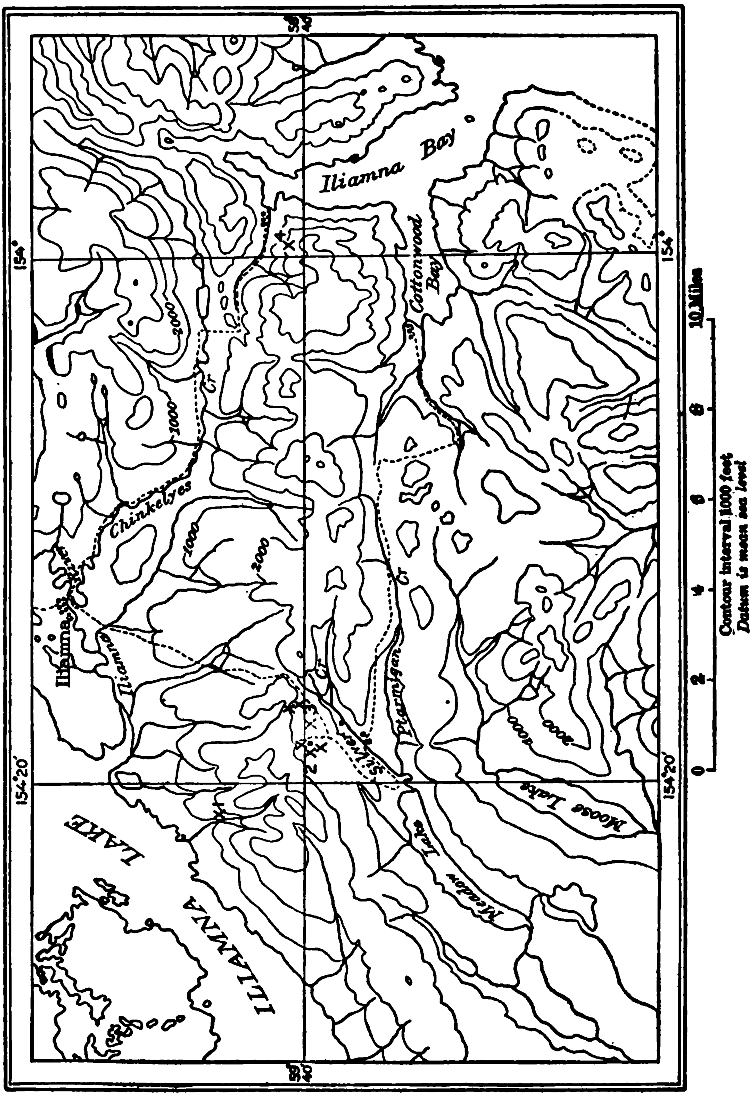


FIGURE 19.—Sketch map showing position of prospects near Iliamna Bay. 1, Durand prospect; 2, Dutton prospect; 3, Duryea prospect; 4, Keyes prospect.

The region is one of bold relief; the neighboring mountain peaks rise abruptly from near sea level to about 4,000 feet. The 12 claims, comprising 203 acres, lie along the flank of one of the higher peaks and extend from a point in a col on the Iliamna village trail, at an elevation of 1,900 feet about 2½ miles southwestward to an elevation of approximately 1,200 feet.

The discovery was made in 1901 by Silas J. Goodro, and the claims were located the following year by the discoverer, Pierce Thomas, and George W. Dutton. The property is now owned by the Dutton Mining & Developing Co. and application has been made for patent. Considerable money was spent on exploratory work, equipment, trails, and buildings during 1904 and 1905, but since then little has been done. The underground workings were inaccessible at the time of the Survey party visit.

The claims are staked along the contact (Pl. II) of limestone with greenstone. This greenstone is an altered igneous rock, originally diabase or diorite. It is a fine-grained rock which in thin section is seen to be composed of plagioclase feldspar, fibrous secondary amphibole (uralite), magnetite, ilmenite, chlorite, epidote, calcite, and quartz. In some areas which are less altered than the greater part of the rock there is a suggestion of original diabase texture.

The limestone, the stratigraphic position of which is described on pages 43–44, is intricately plicated, as is shown in figure 11 (p. 103). The minute folds are closely appressed, stand approximately vertical, and strike parallel to the trend of the limestone outcrops. Within the limestone area there are narrow parallel belts of chloritic schist which seem to be folded or faulted in with the limestone. On the surface the limestone exposures are not continuous, but occur in approximately parallel belts of various widths irregularly disposed. Intervening areas, except for the dikes to be mentioned later, are covered with soil and vegetation. This distribution of the limestones may be the result of folding, which affects them and the associated schists, or of faulting, or very probably of both causes. East of the limestone belt are very dense quartzitic schists which are succeeded farther east by gneisses. A number of small dikes of igneous rock cut the limestone and the greenstone. These dikes are very fine granular porphyritic andesites, very considerably weathered where seen, but not altered to any such extent as the greenstone, and probably are much younger. They were seen both in the limestone near the greenstone contact and along the probable contact of the limestone and greenstone.

The prospective ore bodies of the Dutton claims are included within a zone averaging 200 feet and locally 400 feet in width, which lies along the limestone-greenstone contact and is partly in the greenstone, but chiefly in the limestone. As has been said, the claims are staked on about 2½ miles of the contact, but there are only two areas which seem to have warranted or received considerable development. The larger and principal mineralized area appears, so far as can now be seen, to be about 3,000 feet long; it is included in the length of three claims whose "lode lines" follow the contact, and extends laterally into the three adjoining claims on the southeast. About 1,000 feet farther northeast on the "lode" is the other area, which is largely included within the boundaries of one claim. Ore bodies in these areas which may develop commercial importance will probably be found to be in the form of irregularly distributed bands and shoots.

The mineralization in the greenstone and in some of the less altered dikes is not important in amount or extent. It consists of small, irregular, and discontinuous stringers of pyrite and very little chalcopyrite.

In the limestone area there are pyrite, chalcopyrite, garnet, magnetite, calcite, quartz, epidote, and, much less commonly, chlorite, feldspar, and molybdenite. These are not uniformly developed, but are rather irregularly distributed in bandlike masses paralleling the contact. Garnet and magnetite are not intimately associated with the copper ore. They constitute lenses of nearly pure "garnet rock" or "magnetite rock" and, less abundantly, "garnet-magnetite rock." The magnetite rock is composed preponderantly of minute closely packed crystals of magnetite, with very few small interstices into which they project with crystal outline. The interstices are filled with diopside, fibrous blue-green hornblende, chlorite, calcite, feldspar, and pyrite. The hornblende and chlorite are alteration products of the pyroxene. The pyrite may also be a secondary development in the magnetite rock. It is found with the hornblende and chlorite against which it presents crystal faces. Macroscopically the pyrite seems limited to cracks. The pyrite and feldspar are scarce in the rock.

The garnet rock is made up, in order of relative abundance, of garnets, magnetite, quartz, calcite, and a little pyrite. The order of development seems to be garnet, magnetite, pyrite, quartz, calcite. The garnets are pale brownish-yellow in color and are probably andradite. They range in size from a fraction of a millimeter to 1 centimeter.

The "ore rock" is, on the principal claims, an epidotized limestone containing epidote, calcite, quartz, chalcopyrite, and pyrite. It is made up of fibrous epidote in radial or slightly divergent aggregates and fine granular calcite with some quartz. In this are scattered small cubes of pyrite, for the most part in sharp contact with the epidote and calcite, in some specimens with a thin intervening border of chlorite or calcite. The quartz seems younger than the calcite, being itself without crystal outlines where it touches the epidote, which it appears to surround. The epidote is almost everywhere surrounded by a chlorite fringe which in many places extends into the mass of epidote along cracks, having somewhat the appearance of a secondary product derived from the epidote, but it may be a younger product introduced from without the region of the epidote. The above-described base of the ore rock is interlaced by irregular veinlets, a fraction of an inch to 1 inch in thickness, of quartz and of calcite containing radial or vermicular aggregates of chlorite and chalcopyrite and, in some portions of the ore, also pyrite. This vein calcite and the sulphides are intimately associated. Together they are the youngest constituents in the rock. Much of the vein quartz is strained so as to show undulatory extinction, whereas the vein calcite is not strained and appears in large untwinned grains. Locally this calcite surrounds quartz which has crystal outlines and in some places irregularly interrupts the quartz veins, and in other places separates it from the epidotized rock.

On the claim at the northeast end of the group the "ore rock," as seen on the dump at a shaft, is a schistose limestone composed of calcite and some micaceous minerals. It is not epidotized like the above-described limestone. In this are quartz veins interrupted by veins of pyrite, chalcopyrite, calcite, and quartz intimately intermingled. Pyrite is present in preponderant amount. On this claim molybdenite in minute scattered particles is found in the quartz veins with the iron and copper-iron sulphides, and also as a thin scale on some fractures in the "ore rock." In passing, let it be noted that there is here far too little molybdenite to constitute an ore and that which is present is in too small scales to be concentrated. A surface cut on this claim exposed some small masses, 1 to 2 inches thick, of malachite and iron oxides.

Copper King group.—These claims are about 1½ miles west of the head of Iliamna Bay and one-third mile south of the main trail to Iliamna village, at an elevation of from 1,000 to 1,500 feet above tide. They lie on the steep mountain slope. Nine claims were located in 1905 by the late Charles M. Keyes.

Little has been done to develop the property except the digging of shallow pits and cuts in the regular performance of assessment work.

The prospects lie near the contact of hornblende granite and greenstone. Within the area of the former are small areas of crystalline limestone, with a maximum observed thickness of 20 feet, and irregular nonpersistent masses of garnet rock and magnetite rock. The rock is cut by veins of quartz and epidote. The prospective ore is magnetite rock impregnated with chalcopyrite. According to report the ore is rich, but is irregularly distributed in bodies of small size.

Kasna Creek claims.—Several claims were located in 1906 by Charles Brooks and C. von Hardenberg along Kasna Creek, about 1½ or 2 miles above Kontrashibuna Lake. Kasna Creek is a small stream with steep grade. Its upper valley, glaciated and hanging about 1,000 feet above Kontrashibuna Lake, is surrounded by steep and ragged ridges and peaks between 3,000 and 5,000 feet high. One small hole has been opened on the prospect.

At the Shamrock Ledge discovery the prospect is in a belt of limestone about 2,000 feet wide where examined. The western portion is made up of interlaminated fine argillaceous and fine-grained limestone layers striking nearly north (magnetic), with vertical dip. East of this is dense, hard, blue-gray limestone 100 to 200 feet thick. These rocks are abundantly studded with minute pyrite grains, and the whole weathers a deep rusty red. East of this is the ore body. Its exact boundaries are masked by soil, vegetation, and talus. East of the ore body is a crystalline, rose-colored limestone and coarse white marble. The marble east of the "ledge" is much shattered, and a vertically slickensided surface was noted.

The prospective ore body is a zone about 75 feet wide paralleling the strike of the limestone. In this zone are specular and micaceous hematite, chalcopyrite, pyrite, quartz, calcite, and fibrous, radial amphibole. To some extent these minerals are segregated in several parallel bands. There are on the "Shamrock Ledge" at least two bands of hematite, each about 7 to 10 feet wide, consisting almost entirely of aggregates of specular hematite with a little quartz. Three or four other bands of similar width contain severely shattered, dense, gray limestone, with bunches of amphibole (actinolite?), hematite, quartz, and chalcopyrite. These bands are cut by irregular stringers of chalcopyrite, pyrite, and quartz. There are some stringers of several inches of solid chalcopyrite. Pyrite is not an abundant constituent in any part of the mineralized zone. It was estimated by the writer that the total chalcopyrite content of the "ledge" is under 5 per cent.

There are no oxidized ores or secondary minerals present except a thin surface film of limonite and copper carbonates.

Millet claims.—The claims of O. B. Millet, located in 1906 and thereafter, are on the north shore of Iliamna Lake about 22 miles west of Iliamna village. The four important claims lie along a "ledge" which runs N. 35°–40° W. (magnetic) up a low knoll from a small bight on the lake shore. The property has been developed by seven open cuts each crossing the entire width of the mineralized body.

The prospect is on a fine-grained crystalline bluish-white limestone and parallels the contact of a dark, fine-grained diabase. This contact is not exposed, and therefore its nature is not known. Near the lake shore both diabase and limestone are overlain by a thin capping of tuffaceous porphyries.

The "ledge" is for the most part covered by soil and vegetation. Where it outcrops it is inconspicuous and was detected only because limonite and a very little copper stain distinguished it from the inclosing limestone. From the northern edge of the tuffaceous capping, that is, about 2,500 feet from the lake shore, the "ledge" has been traced for 3,500 feet. Through this distance it approximately parallels the diabase contact at a distance of about 100 or 150 feet. The "ledge" or "ore body" ranges from 22 feet to 42 feet in width. Both walls are crystalline limestone, grayish blue to white, much shattered and healed by white calcite seams. The limits of mineralization are sharply marked. The ore body itself is a dark bluish, more or less coarsely crystallized limestone. It is traversed at intervals of 1 to 8 or 10 feet by fracture zones in which the limestone is intricately shattered, cemented by calcite and sulphides, refractured, slickensided, and recemented. These fracture zones are a fraction of an inch to 1 foot wide. Although very irregular, they have a general trend N. 35° to 40° W. (magnetic) and dips 75° to 90° NE.

The mineralization is by chalcopyrite, pyrite, calcite, and quartz. The sulphides to some extent impregnate the limestone, but in much larger amounts appear with calcite as vein fillings. These veins are broken, intricately crumpled and slickensided. The calcite in them is coarsely recrystallized and the fractures have been refilled by calcite, quartz, and small amounts of sulphides. Ten per cent copper and small values in precious metals are reported to have been obtained from picked samples.

Durand prospect.—Two claims have been staked on the mountain side about 2½ miles below the mouth of Iliamna River and 1 mile from the shore of Pile Bay at an elevation of 1,000 feet. Two shallow prospect pits have been opened on a 10-foot quartz vein, striking N. 80° E. (magnetic) and dipping 45° NE. The surrounding rock is a schistose greenstone. The vein contains fairly uniformly disseminated masses of chalcopyrite and pyrite. Azurite and malachite in small masses were seen in weathered parts of the vein. The hanging wall is impregnated with pyrite for 4 feet from the vein.

A possible extension of this mineralized zone was seen on the opposite side of the mountain 2 miles south of the Durand prospect, where C. E. Giffin noted a 2-foot quartz vein carrying pyrite and a 40-inch vein striking north with high westerly to vertical dip, which contained quartz, epidote, and chalcopyrite. The country rock is greenstone.

Knutson prospect.—This property was not visited by the Survey party. It is reported to be about 2 miles back from the entrance to Knutson Bay on the north shore of Iliamna Lake, at an elevation of 1,300 feet. The ledge is said to be a vein of white quartz 3 to 8 feet wide, slightly and irregularly mineralized with copper ores and gold. The country rock is granite.

A similar but narrower vein is said to parallel the Knutson vein at a distance of one-fourth mile.

SILVER.

OCCURRENCE OF THE ORES.

Silver prospects are known at one locality only. This is on the limestone belt extending southwesterly from Iliamna village on which the Dutton copper prospects are located. The silver claims have been staked on the eastern part of the limestone adjoining the copper claims and are in the aggregate about 2 miles in length. However, but one group of 8 claims, belonging to W. E. Duryea and E. Duryea, has been developed, so that investigation was possible. The following description, therefore, applies only to the Duryea properties.

SILVER-BEARING MINERALS.

Exploration in the Iliamna region has not disclosed any silver minerals except argentiferous galena (the sulphide of lead) and argentiferous sphalerite (the sulphide of zinc), which are also manganiferous and which occur in veins now being prospected for their silver content. Besides these minerals manganiferous limonite and lead-bearing ocher, small amounts of smithsonite (zinc carbonate) and selenite (lime sulphate) are in the weathered parts of the veins. Pyrite is only locally and sparingly developed. Calcite and quartz, in veins which have been crushed, are found near the metalliferous veins, but do not occur as gangue minerals in them.

DESCRIPTIONS OF CLAIMS.

Duryea claims.—The limestone on these claims, which has the general structure indicated in figure 11 (p. 103), has been cut nearly at right angles to its strike by many small vertical dikes, of which 27 were seen which had widths of 3 feet or less. Several larger dikes and irregular masses were also observed, most of which are parallel to the strike of the limestone.

Small masses and nodules of black manganiferous iron oxide have been found at a number of places on the bare limestone surface, and wherever these localities have been explored by test pits argentiferous galena-sphalerite bodies have been found along fissures in the limestone. The fracture zones appear to be vertical. Along them the limestone is brecciated and some pieces are slickensided. It appears from the material collected that the sphalerite, galena, and small amounts of pyrite filled the fractures. To some extent also the limestone is impregnated with these sulphides. As none of the openings have exposed ore below the zone of weathering the sulphides of the examined material are considerably oxidized and the limestone decayed by solution due to surface waters. Consequently it has been impossible to determine whether there has been replacement of the limestone. From the abundance of limonite and the fact that considerable limonite is present with the least weathered galena and sphalerite it seems probable that more pyrite will be found in the unoxidized ore.

Near the eastern margin of the limestones on the Duryea claims the distribution of patches of manganiferous gossan and the exposures in the various test pits seem to indicate that for about 5,000 feet there is more or less persistent mineralization on a fissured zone in the limestone striking about 20° east of north (magnetic) and approximately vertical. A cliff on a tributary gulch of Silver Creek crosses this zone and exposes, through a height of 50 feet or more, much oxidized ledge matter. The width of this zone was not determinable from what was visible at the time of the examination. The owners estimate it at 75 feet. The distribution of other showings on the surface and in the test pits would seem to indicate that there has been mineralization along various fractures or fracture zones.

The owners of these claims report that samples have yielded from 80 to 196 ounces of silver, 0 to $20 of gold, 35 to 50 per cent lead, and 15 to 20 per cent zinc. The black manganiferous gossan, they report, carries 2 to 6 ounces of silver.

Other silver claims have been staked on the same limestone belt, but no ore was seen on the surface and no development work has been done on them.

GOLD.

LODES.

Claims on Iliamna Bay.—Several lode claims have been staked on or near the shores of Iliamna Bay. One of these is on Diamond Point, near the entrance to Cottonwood Bay. The country rock is granite locally intruded by small dikes of porphyry. Several hundred feet to the north and west the granite is in contact with a large mass of greenstone. The supposed ore body consists of a shattered and much weathered zone 4 to 12 feet wide on Iliamna Bay, and apparently 100 feet or more in width on Cottonwood Bay, in which the granite is thoroughly crushed and impregnated with narrow veins and stringers of pyrite. No other sulphides were recognized and no authentic information could be obtained concerning assay values, although it was rumored that $2 per ton in gold had been obtained.

Aukney claim.—This claim was located in 1908, presumably on account of a supposed gold content. It is situated on the south shore of Iliamna Lake, 23 miles from the outlet of the lake.

The rocks as exposed in the lake cliffs consist of tuffs (quartz latite tuff) striking parallel to the shore (northeast) and dipping from vertical to 75° SE. They contain much fine disseminated pyrite which, where oxidized, gives them a bright yellow stain. No sulphides other than pyrite could be recognized, and nothing is known as to what precious metals, if any, are present.

The only work done on the claim is a little blasting on the face of the cliff.

PLACERS.

The effort to discover placers on the drainage tributary to Lake Clark from the north has not met with encouraging results. Prospects have been found on Caribou Creek, a northeasterly tributary to Chulitna River; on Kellet Creek and Ingersol, Lincoln, and Franklin gulches, which are headwaters of Kijik River; and on Portage Creek which enters Lake Clark about 35 miles above the outlet of the lake and which heads against the last-mentioned streams. These streams were not visited by the Survey party, and little information about them was obtained. Two men are reported to have done considerable work on Portage Creek, which netted a few hundred dollars' worth of coarse gold. It was further reported that they found the alluvium to be about 12 feet deep and composed chiefly of large glacial bowlders.

PETROLEUM.

The lowlands on the coast of Cook Inlet, especially between Chinitna and Iniskin bays, have been quite extensively staked as petroleum land and several wells have been drilled. The geology and indications of petroleum in this district have been already described in several reports[1] from which the facts presented below are taken.

SURFACE INDICATIONS.

The surface indications of petroleum in this region consist of seepages or oil springs and the so-called "gas springs." In the seepages the petroleum may be seen oozing from the cracks in the rock or from the soil. A copious seepage was seen on the east shore of Iniskin Bay, about 1,000 feet below the lower cabin, between high and low tide. The flow is more or less intermittent, and is often so strong that the petroleum collects in large blotches on the pool or even covers its entire surface. At one point in this seepage the oil was seen to issue from a crevice in the shale of the upper part of the Tuxedni sandstone.

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[1] Martin, G. C., The petroleum fields of the Pacific coast of Alaska: Bull. U. S. Geol. Survey No. 250, 1905, pp. 37–49; Notes on the petroleum fields of Alaska: Bull. U. S. Geol. Survey No. 259, 1905, pp. 128–139.

A number of large seepages are reported to be near the cabin at Oil Bay. From the bottom of one of these the petroleum rose almost continually, the flow varying, however, from time to time, now almost ceasing, now becoming very strong. It is frequently possible to skim several quarts of petroleum from the surface of the pool, as was done for the test recorded on page 129.

About 2 miles west of the beach at Dry Bay is a so-called "gas spring," in which gas of unknown composition rises in a continuous stream of bubbles to the surface of the water. From the north shore of Chinitna Bay both oil and gas springs have been reported, but they were not seen by the writer.

All these seepages and gas springs are on the outcrop of the Tuxedni sandstone. Their structural position is a short distance northwest of the monocline described above (pp. 96–99) as extending parallel to the coast. A broad flat-topped anticline is believed to lie northwest of this monocline, although there is evidence (fig. 7, p. 99) that the structure may be further complicated by the presence of a fault, which marks the northwest edge of the belt of monoclinal dip. The seepages are situated at or very close to the line on which the dip changes from nearly horizontal to steeply inclined. If the fault is present throughout this belt the seepages are probablv situated on or near it and are intimately related to it genetically.

Seepages are also reported from the shores of Kamishak Bay, especially on the south shore at Douglas River. The rocks in this region, as far as seen by the writer, are the shales, sandstones, and conglomerates of the Naknek formation. They are horizontal or have very gentle dips over large areas, and this district would seem to be more promising as a prospective oil field than the district in which the drilling was done. This is, however, a difficult place to land machinery, for the bays are all shallow and filled with rocks, while numerous uncharted reefs extend out many miles from shore into Cook Inlet.

DEVELOPMENTS.

Indications of petroleum are reported to have been first discovered in this region about 50 years ago. The first samples are said to have been taken out in 1882 by a Russian named Paveloff. Claims are said to have been staked by Edelman in 1892. His location was near the divide at the head of the creeks entering Oil and Dry bays, and the claims were subsequently abandoned. In 1896 Pomeroy and Griffen staked claims at Oil Bay and during the next year organized the Alaska Petroleum Co., which began work in 1898. The Alaska Oil Co. was organized in 1901 and in 1902 began drilling at Dry Bay.

The first well at Oil Bay was begun in 1898 and is said to have been drilled to a depth of somewhat over 1,000 feet. No log of this well or any very authentic information can be obtained, as the property has changed management several times. It is reported that gas was encountered all the way below 190 feet and that considerable oil was found at a depth of 700 feet. The flow of oil is reported as estimated at 50 barrels per day. On drilling deeper a strong water pressure was encountered, which shut off the flow of oil. The well is now over 1,000 feet in depth and affords a continuous flow of gas, which at times becomes very strong. Attempts have been made to shut off the flow of water and either recover the lost oil or drill deeper, but without success.

A second well, located about a quarter of a mile west of the older one at Oil Bay, was drilled during the summer of 1904. The log of this well is given below.

Record of well at Oil Bay.[1]

	Feet.
Sandstone	200
Shale	120
Oil and some gas	1
Shale (caving)	129
	450

The well was abandoned at a depth of 450 feet because the shale caved so badly.

A third well, located about 250 feet south of the last, was also drilled during the summer of 1904. The general sequence of strata is reported to be the same as in the second well described above, the shale continuing to the bottom of the hole. The well was cased to a depth of 630 feet. Oil and gas were reported at a depth of 770 feet, there being three small oil sands, each 6 to 8 inches thick and 4 or 5 feet apart. The well was estimated at 10 barrels per day. The caving rock was encountered at 830 feet. Work was stopped at a depth of 900 feet at the end of the season. Considerable gas was encountered at various depths, at times the pressure being strong enough to blow the water up in the derrick to a height of 20 feet.[2]

A well at Dry Bay was drilled to a depth of 320 feet in the summer of 1902 without encountering oil. The tools were then lost and the hole abandoned. In August, 1903, a new well was started in close proximity to the first, but not much was accomplished, and work was discontinued a few months later because of an accident to the machinery.

No information is available concerning operations in 1905 and 1906. No drilling has been done since 1906 and the oil camps are now abandoned.

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[1] Reported by August Bowser.

[2] Information in this paragraph furnished by August Bowser.

CHARACTER OF THE PETROLEUM.

A sample of the seepage petroleum from Oil Bay was collected by the writer by skimming the oil from the surface of the water where it was continually rising from the bottom of the pool. An effort was made to obtain as much of the fresher oil as possible. Vegetable and earthy impurities were removed by straining through coarse cloth. Water could not be entirely removed. Oil for lubricating purposes at the neighboring wells has been obtained from these pools in this manner.

The fresher oil is dark green. That which has remained on the surface of the pool for some time is dark brown.

The oil has doubtless lost a large part of its volatile constituents. The analyses therefore do not represent the composition which could be expected of the live oil from wells in this region. Such oil would have a lower specific gravity, higher percentage of the more volatile constituents, and lower percentage of the less volatile constituents, residue, and sulphur. It would certainly be better than these samples in all respects, and would resemble them in having a paraffin base, and would doubtless be a refining oil.

This sample was submitted to Penniman & Browne, of Baltimore, who return the following report on their tests:

Tests of sample of seepage petroleum from Oil Bay.

	Per cent.	Gravity (°Baumé).
Distillation by Engler's method:		
Burning oil (distillation up to 300° C., under atmospheric pressure)	13.2	29.5
Lubricating oils (spindle oils) (120 mm. pressure, up to 300° C.)	39.2	22.6
Lubricating oils (120 mm. pressure, 300–350° C.)	19.6	17.9
Paraffin oils (by destructive distillation under atmospheric pressure)	22.4	20.4
Coke and loss	5.6	....
Total	100.00	
Total sulphur	0.098	....
Specific gravity of crude oil at 60° F., 0.9557, or 16.5° Baumé.		
Initial boiling point, 230° C.		

The distillation of the lubricating oils under diminished pressure, corresponding to refinery practice, was carried on until signs of decomposition set in. The resulting residue was unsuitable for making cylinder stock, and was therefore distilled for paraffin oils. These paraffin oils contain a considerable quantity of solid paraffin. It was not practicable to determine the amount of the material with the small amount of oil at our disposal.

The iodine absorption of the oils and distillates has been determined by Hanus's method (solution standing 4 hours), and is here tabulated:

Iodine absorption of oils and distillates from Oil Bay.

	Per cent of iodine.
Burning oil	17.8
Lubricating oil	26.2
Heavy lubricating oil	35.8

These iodine numbers upon the lubricating oils were obtained upon the samples. For comparison, samples of similar oils were obtained from the Standard Oil Co., and the iodine numbers determined as follows:

Iodine absorption of commercial oils.

	Per cent of iodine.
Light distilled lubricating oil (spindle oil)	32.0
Dark lubricating oil (engine oil)	45.4

The burning oils were tested in a small lamp and found to give a good flame. All the oil was consumed without incrusting the wick or corroding the burner.

The oil has a paraffin base, and the products of distillation are "sweet." We are informed that this sample is a "seepage oil." If a sufficient yield can be obtained by drilling, a very suitable oil for refinery purposes may be expected, containing a very much larger quantity of the more desirable lighter products.

NOTES ON THE MULCHATNA REGION.[1]

INTRODUCTORY STATEMENT.

The Mulchatna Valley lies between the valleys of Lake Clark and of Kuskokwim River, as is shown in figure 20. Mulchatna River rises opposite the south fork of the Kuskokwim River, in the mountains north and northeast of Lake Clark, which are the southern extension of the Tordillo Mountains of Spurr. Three

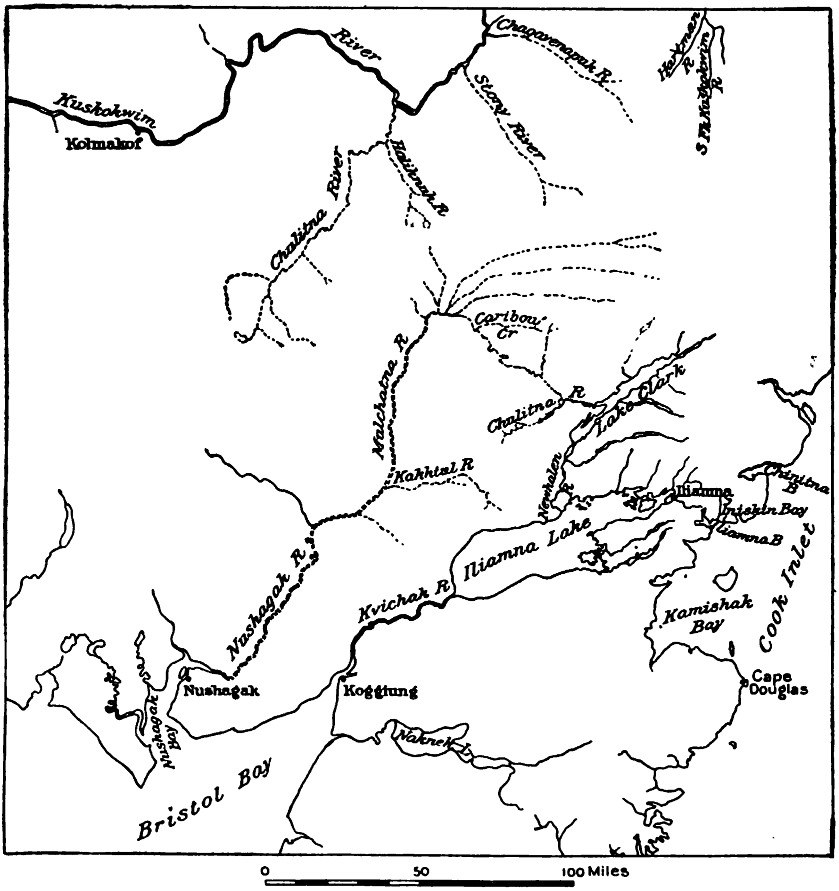

FIGURE 20.—Sketch map showing geographic relation of the Mulchatna district to the neighboring regions.

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[1] The Mulchatna region has not been visited by Survey parties. The notes here given were obtained from prospectors and traders who are personally familiar with the region.

main branches, known as the Big, the Middle, and the Small Mulchatna, flow southwesterly to a point about 25 miles north of the west end of Lake Clark where they unite to form the main Mulchatna. Thence the stream flows about 60 miles southwest to its confluence with the Tikchik from the northwest, receiving in this interval one important tributary, the Koktalee or Kakhtul. Nushagak River, which is formed by the confluence of the Tikchik and Mulchatna, takes a southwesterly and westerly course for 90 miles to Bristol Bay on Bering Sea. Above the forks of the Mulchatna the country is mountainous with moderate relief; below the forks, it is low with broad gravel-covered, pond-dotted plains and detached hills or mountains.

ROUTES AND SUPPLY POINTS.

Canoes can be taken from Bristol Bay up to the Koktalee and, it is reported, to the forks of the Mulchatna and even beyond in high water. The usual route, however, is from Iliamna, generally from Iliamna Bay on Cook Inlet by portage trail to Iliamna village, thence by boat to Newhalen River and Lake Clark. From Lake Clark the trail is either overland from Portage Bay or by boat up Chulitna River, and thence overland. From Koggiung on Bristol Bay another boat route ascends the Kvichak and crosses Iliamna Lake. There are boats and boatmen for hire at Koggiung, Iliamna, and on Lake Clark, and pack animals or natives are usually available for work on the portages. Supplies of all kinds can be purchased at Iliamna, and the local traders have stocked caches with provisions on Lake Clark and on the Mulchatna. It is reported that the trails are good, that horses can be readily used, and that on the whole the region is more accessible than others in Alaska which have received more attention. During 1910 a company was organized to establish a trading post on the Mulchatna and built a small steamer for service between Bristol Bay and the head of steamboat navigation on Mulchatna River. The ocean steamboat service to Bristol Bay and Iliamna Bay is described on pages 21–23.

It is not known how many men have visited the Mulchatna from time to time. Sixteen were there during the summer of 1909, of whom six planned to remain during the winter, and others were coming in at the time the Survey party was leaving Iliamna. In the summer of 1910 there were some 15 or 20 prospectors in the region. In the fall of 1909 those interested organized the Mulchatna mining precinct and elected a recorder, though there is and has been for some time a United States commissioner with headquarters and recording office at Iliamna, whose district includes the Mulchatna.

PROSPECTS.

On the Mulchatna, from the Koktalee up, and on the Koktalee, also, fine flour gold is found on all the river bars. Bedrock has not yet been prospected along these larger streams on account of ground water. Only summer work has been attempted so far, and as yet no permanent ground frost has been encountered. It is claimed that after May 15 no thawing is required. Above the forks of the Mulchatna, particularly on the middle fork, the gold so far found is coarser, and there is said to be pay. Some of the smaller tributaries carry coarse gold. On one of them two men opened a hole in 1909 and took out about $8 worth of coarse gold.

The prospecting so far has been confined to the present stream beds. The pay is said to be practically all on bedrock, which is reported by the prospectors to be chiefly slate. Limestone and "porphyry" bedrock also are reported. The gravels prospected are generally from 4 to 12 feet deep; one hole is 16 feet deep.

Water is plentiful, and grades are sufficient for sluicing. Timber is abundant on all the streams.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 486

RESULTS OF SPIRIT LEVELING IN COLORADO

1896 TO 1910, INCLUSIVE

R. B. MARSHALL, CHIEF GEOGRAPHER

WASHINGTON
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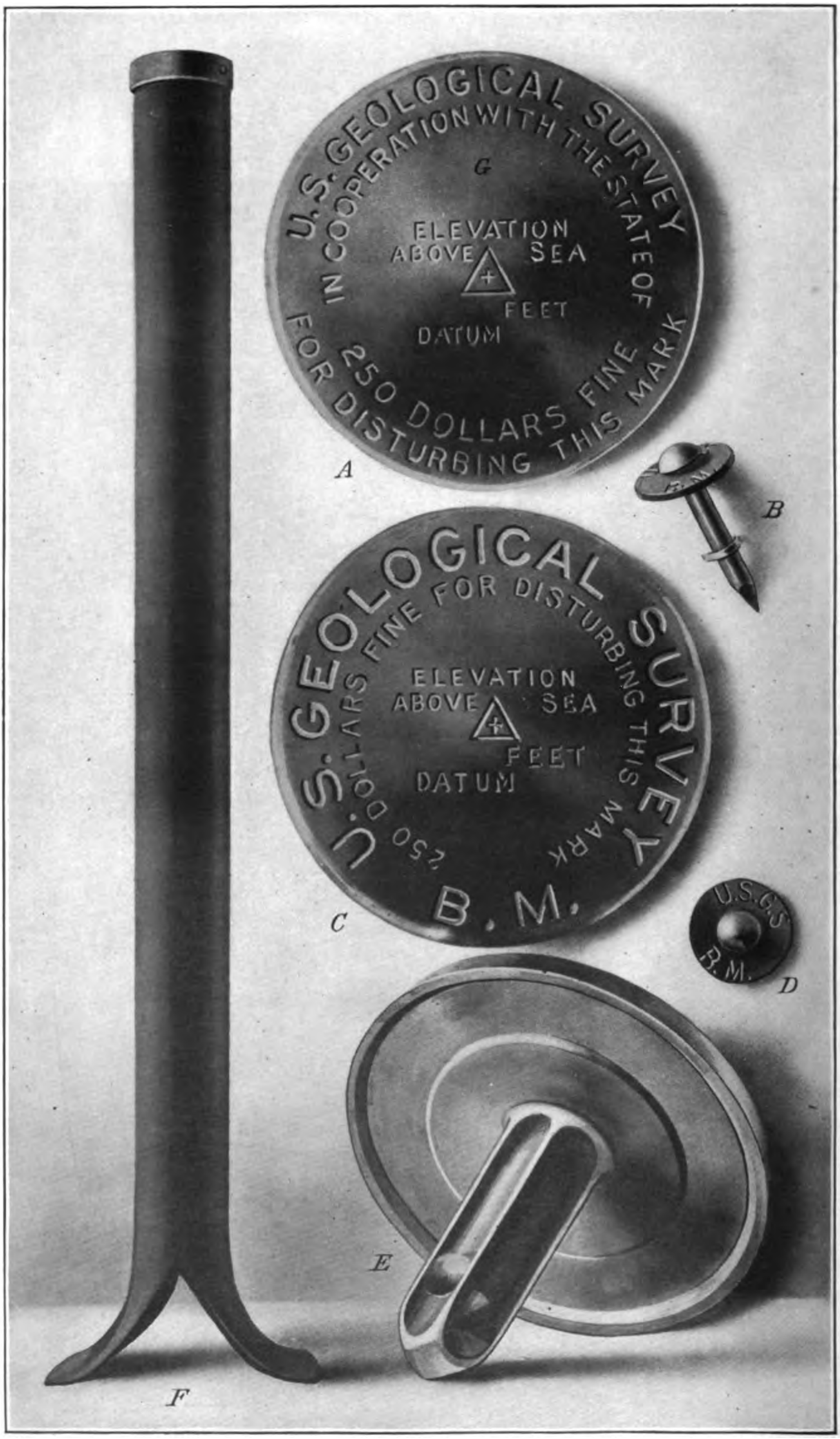

GEOLOGICAL SURVEY BENCH MARKS.

A, Tablet used in cooperating States. The State name is inserted at *G*.
B and *D*, Copper temporary bench mark, consisting of a nail and copper washer.
A, *C*, and *E*, Tablets for stone or concrete structures.
F, Iron post used where there is no rock.

RESULTS OF SPIRIT LEVELING IN COLORADO, 1896 TO 1910, INCLUSIVE.

R. B. MARSHALL, Chief Geographer.

INTRODUCTION.

Scope of the work.—All results of spirit leveling in Colorado previously published by the United States Geological Survey and all the results of later work are included in this report, rearranged by quadrangles. Nearly all elevations are based on preliminary 1911 adjustment heights of bench marks along the precise level lines of the Coast and Geodetic Survey from Colorado Springs, Colo., via Denver to Laramie, Wyo., and on Coast and Geodetic Survey precise bench marks near Albuquerque, N. Mex., connection having been made by precise and primary leveling of the United States Geological Survey.

Personnel.—The field work from 1896 to 1906, inclusive, was done under the general direction of E. M. Douglas, geographer; that for 1907 to 1909, inclusive, under E. C. Barnard, geographer; and the later work under Sledge Tatum, geographer, under the general direction of R. B. Marshall, chief geographer. The names of the various levelmen are given in the introduction to each list. The office work of computation, adjustment, and preparation of lists was done mainly by S. S. Gannett, geographer, and D. H. Baldwin, topographer, and since 1907 under the general direction of E. M. Douglas, geographer.

Classification.—The elevations are classified as precise or primary, according to the methods employed in their determination. For precise-level lines instruments and rods of the highest grade are used, each line is run in both forward and backward directions, and every precaution is taken to guard against error. The allowable divergence between the forward and the backward lines in feet is represented by the formula $0.017\sqrt{D}$, in which D is the distance in miles between bench marks. For primary lines standard Y-levels are used; lines are run in circuits or are closed on precise lines, with an allowable closing error in feet represented by $0.05\sqrt{D}$, in which D is the length of the circuit in miles, sufficient care being given to the work to maintain this standard. For levels of both classes careful office adjustments are made, the small outstanding errors being distributed over the lines. Orthometric corrections have been applied in determining the following elevations.

Bench marks.—The standard bench marks are of two forms. The first form is a circular bronze or aluminum tablet (*C* and *E*, Pl. I), 3½ inches in diameter and one-fourth inch thick, having a 3-inch stem, which is cemented in a drill hole in solid rock in the wall of some public building, a bridge abutment, or other substantial masonry structure. The second form (*F*, Pl. I), used where masonry or rock is not available, consists of a hollow wrought-iron post 3½ inches in outer diameter and 4 feet in length after being split at the bottom and expanded to a width of 10 inches in order to give a firm bearing on the earth. A bronze or aluminum-bronze cap is riveted over the top of the post, which is set about 3 feet in the ground. A third style of bench mark with abbreviated lettering (*B* and *D*, Pl. I), is used for unimportant points. This consists of a special copper nail, 1½ inches in length, driven through a copper washer seven-eighths of an inch in diameter.

The tablets, as well as the caps on the iron posts, are appropriately lettered, and State cooperation is indicated by the addition of the State name (*G*, Pl. I).

The numbers stamped on the bench marks described in the following pages represent the elevations to the nearest foot, as determined by the levelman. These numbers are stamped with $\frac{3}{16}$-inch steel dies on the tablets or post caps, to the left of the word "feet." The office adjustment of the notes and the reduction to mean sea level datum may so change some of the figures that the original markings are 1 or 2 feet in error. It is assumed that engineers and others who have occasion to use the bench-mark elevations will apply to the Director of the United States Geological Survey at Washington, D. C., for the adjusted values, and will use the markings as identification numbers only.

Datum.—All United States Geological Survey elevations are referred to mean sea level, which is the level that the sea would assume if the influence of tides and winds were eliminated. This level is not the elevation determined from the mean of the highest and the lowest tides, nor is it the half sum of the mean of all the high tides and the mean of all the low tides, which is called the half-tide level. *Mean sea level is the average height of the water, all stages of the tide being considered.* It is determined from observations made by means of tidal gages placed at stations where local conditions, such as long narrow bays, rivers, and like features will not affect the height of the water. To obtain even approximately correct results these observations must extend over at least one lunar month, and if accuracy is desired they must extend over several years. At ocean stations the half-tide level and the mean sea level usually differ but little. It is assumed that there is no difference between the mean sea level as determined from observations in the Atlantic Ocean, the Gulf of Mexico, or the Pacific Ocean.

The connection with tidal stations for bench marks in certain areas that lie at some distance from the seacoast is still uncertain, and this fact is indicated by the addition of a letter or word to the right of the word "Datum" on tablets or posts. For such areas corrections of published results will be made from time to time as the precise-level lines of the United States Geological Survey or other Government organizations are extended.

Topographic maps.—Maps of the following quadrangles, wholly or partly in Colorado, have been published by the United States Geological Survey up to May 6, 1911. They may be obtained (except as noted) for 5 cents each, or $3 a hundred, on application to the Director of the Survey at Washington, D. C.:

Abajo (Utah-Colo.).
Albany (Colo.-Kans.).
Anthracite.
Apishapa.
* Arkansas River drainage basin.
Arroyo.
Ashley (Utah-Colo.).
Aspen.
Aspen special.
Big Springs.
Blackhawk.[1]
Boulder.
Breckenridge special.
Canon City.
Castle Rock.
Catlin.
Central City.
Central City special.
Cheyenne Wells (Colo.-Kans.).
Colorado Springs.
Crested Butte.
Cripple Creek special.
Danforth Hills.
Denver (double sheet).[2] 10 cents.
Durango.[3]
* East Denver.[2]
East Tavaputs (Utah-Colo.).
Eaton.
Elmoro.
Encampment special (Wyo.-Colo.).
Engineer Mountain.
Fort Collins.[4]
Georgetown.
Granada (Colo.-Kans.).
Grand Hogback.
Greeley.
Higbee.
Huerfano Park.
Idaho Springs special.
Ignacio.
Jensen (Utah-Colo.).
Kit Carson.
Lake City.
Lamar.
La Plata.
La Sal (Utah-Colo.).

---

* Out of print.

[1] Shows wooded areas.

[2] Denver double sheet includes East Denver sheet and the results of surveys of about half the similar quadrangle next west.

[3] Durango sheet, on scale of 1 : 62500, has been reduced and forms part of Ignacio sheet, on scale of 1 : 125000.

[4] Fort Collins sheet, on scale of 1 : 62500, has been reduced and forms part of Livermore sheet, on scale of 1 : 125000.

Las Animas.
Leadville.
Leadville special.
Limon.
Livermore.[1]
Loveland.
Medicine Bow (Wyo.-Colo.).
Mesa de Maya.
Mount Carrizo.
Mount Olympus.
Meedle Mountains.
Nepesta.
Niwot.
Ouray.
Pikes Peak.
Pikes Peak special. 10 cents.
Platte Canyon.
Pueblo.
Rangely.
Rico.
Rico special.
Sanborn.
San Cristobal.[2]
Silver Plume special.
Silverton.
Spanish Peaks.
Springfield.
Telluride.
Tenmile district special.
Timpas.
Two Butte.
Uncompahgre.
Vilas (Colo.-Kans.).
Walsenburg.
White River.

PRECISE LEVELING.

Cameo, Como, Delta, Denver, Eagle, Glenwood Springs, Grand Junction, Hotchkiss, Leadville, Montrose, Mount Powell, Platte Canyon, and Rifle quadrangles.

ARAPAHOE, D[illegible]AS, EAGLE, GARFIELD, JEFFERSON, LAKE, MESA, MONTROSE, OURAY, PARK, AND SUMMIT COUNTIES.

The [illegible]s in this list are based on a bench mark of the Coast and Geodetic Survey near Denver, Colo., described as follows: "Petersburg, 1 mile north of, bottom of a chiseled square on second step of northeast abutment of the Denver & Rio Grande Railroad bridge." Its elevation is accepted as 5,281.101 feet by the preliminary adjustment of 1911.

The leveling was done in 1908 by C. H. Semper.

DENVER QUADRANGLE.

Denver via Denver & Rio Grande R. R. to Acequia, thence west along road and Colorado & Southern Ry. to Platte Canyon.

	Feet.
Petersburg, 1 mile north of, on second step from top of north stone abutment of Denver & Rio Grande R. R. bridge, east of track; bottom of chiseled square (Coast and Geodetic Survey bench mark)	5,281.101
Littleton, 1.09 miles north of, on top step, east side of south abutment of railroad bridge; bottom of chiseled hole	5,327.43
Littleton, Denver & Rio Grande R. R. station, in the end of a copper bolt in stone; intersection of cross (Coast and Geodetic Survey bench mark)	5,362.076
Wolhurst, opposite station; top of rail	5,404.9
Wolhurst, 1,075 feet south of, in top of retaining wall at south end of railroad culvert west of track; aluminum tablet stamped "5409"	5,407.820

---

[1] Fort Collins sheet, on scale of 1 : 62500, has been reduced and forms part of Livermore sheet, on scale of 1 : 125000.

[2] Shows wooded area.

	Feet.
Acequia, 0.5 mile north of, on top of northeast end of retaining wall for railroad culvert; chiseled square, lettered U S □ B M (Coast and Geodetic Survey bench mark)	5,503.637 C. S. 5,503.457 G. S.
Acequia, 0.91 mile northwest of, in root of poplar tree north of road, between Denver & Rio Grande R. R. and Colorado & Southern Ry., at three corners; spike	5,411.73
Willard, 1.14 miles north of, 100 feet east of track, in southwest abutment of highway bridge; aluminum tablet stamped "5404"	5,402.849
Willard, 1.71 miles south of, in northeast abutment of culvert; aluminum tablet stamped "5455"	5,454.460

PLATTE CANYON QUADRANGLE.

Platte Canyon along Colorado & Southern Ry. to Bailey.

	Feet.
Platte Canyon, in front of station; top of rail	5,509.4
Platte Canyon, 1.04 miles south of, 25 feet west of track, 3 feet north of telegraph pole, at north end of trestle 1037, in granite outcrop; aluminum tablet stamped "5544"	5,542.865
Platte Canyon, 2.10 miles south of, 210 feet north of head gate in Platte River, 5 feet west of track, on top of large bowlder; square, marked "U. S. 5592 B. M."	5,591.452
Platte Canyon, 3.72 miles south of, in top of wing wal[illegible] abutment of steel bridge over Platte River; aluminu[illegible] stamped "5671"	[illegible]670.247
Mill Gulch, in front of signboard; top of rail	5,686.4
Strontia Springs, 1.52 miles north of, 15 feet east of track, on bowlder; point in square marked "U. S. B. M. 5736"	5,735.600
Strontia Springs, 0.67 mile north of, east of track, on bowlder; point in square marked "U. S. B. M. 5798"	5,796.859
Strontia Springs, in front face of Strontia Springs Hotel; aluminum tablet stamped "5864"	5,862.971
Strontia Springs, 1.24 miles south of, west of track, on bowlder; point in square marked "U. S. B. M. 5994"	5,993.710
Strontia Springs, 2.25 miles south of, west of track, on bowlder; point in square marked "U. S. B. M. 6087"	6,086.342
South Platte, in front of station; top of rail	6,093.1
South Platte, 160 feet south of, at west edge of park fence, in bowlder; aluminum tablet stamped "6094"	6,093.369
South Platte, 1.12 miles south of, west of track at small flume crossing river, on rock; point in square marked "U. S. B. M. 6138"	6,137.666
Dome Rock, 900 feet north of, west of track, on rock; point in square marked "U. S. B. M. 6208"	6,207.230
Dome Rock, in front of station; top of rail	6,215.8
Dome Rock, 800 feet south of, in top of front foundation of water tank; aluminum tablet stamped "6229"	6,228.791
Dome Rock, 1.05 miles south of, west of track, on rock; point in square marked "U. S. B. M. 6266"	6,265.835
Dome Rock, 2.28 miles south of, 60 feet west of track, in small flat, on large bowlder; point in square marked "U. S. B. M. 6359"	6,358.760

	Feet.
Stone, 204 feet south of signboard, in west side of stone abutment of culvert; aluminum tablet stamped "6425"	6,424.449
Petershead, in front of station sign; top of rail	6,485.9
Petershead, 120 feet south of, 6 feet east of track, on large granite bowlder; point in square marked "U. S. B. M. 6488"	6,487.215
Ferndale, 1,100 feet north of, 12 feet west of track, in granite outcrop; aluminum tablet stamped "6539"	6,538.618
Ferndale, in front of signboard; top of rail	6,548.7
Ferndale, 0.57 mile south of, west of track, in bowlder; point in square marked "U. S. B. M. 6596"	6,595.111
Riverview, in front of signboard; top of rail	6,604.0
Buffalo, in front of station; top of rail	6,629.7
Buffalo, in front face of J. W. Green's store; aluminum tablet stamped "6634"	6,633.377
Buffalo, 1 mile west of, north of track, on rock; point in square marked "U. S. B. M. 6680"	6,678.976
Pine Grove, in front of station; top of rail	6,754.4
Pine Grove, 295 feet west of station, 80 feet north of track, in east corner stone of fence around Columbine Cottage; aluminum tablet stamped "6766"	6,765.436
Crystal Lake, in front of signboard; top of rail	6,762.9
Crystal Lake, 0.46 mile west of, north of track, on rock; point in square marked "U. S. B. M. 6789"	6,788.726
Carla, in front of signboard; top of rail	6,844.5
Carla, 0.29 mile west of, north of track, on rock; point in square marked "U. S. B. M. 6854"	6,853.439
Glenmore Lakes, in front of signboard; top of rail	6,880.5
Cliff, 950 feet north of, 6 feet east of track, in top of large bowlder; aluminum tablet stamped "6916"	6,915.470
Cliff, in front of station; top of rail	6,923.4
Cliff, 1.66 miles west of, south of track, on rock; point in square marked "U. S. B. M. 7068"	7,067.337
Crosson, in front of signboard; top of rail	7,071.4
Crosson, 15 feet north of track, 150 feet north of milepost 49, in bowlder; aluminum tablet stamped "7236"	7,235.619
Crosson, 1.22 miles west of, on top of retaining wall of northeast abutment of steel bridge over Platte River; square marked "U. S. B. M. 7388"	7,387.522
Crosson, 2.27 miles west of, 150 feet east of milepost 51, south of track, on rock: point in square marked "U. S. B. M. 7529"	7,528.400
Estabrook, 1,800 feet west of, in southeast abutment of steel bridge over river; aluminum tablet stamped "7572"	7,571.743
Insmont, 650 feet east of, 160 feet west of milepost 53, north of track, on outcrop of rock; point in square marked "U. S. B. M. 7660"	7,659.580
Insmont, in front of station; top of rail	7,660.5
Fairview, in front of station; top of rail	7,689.5
Fairview, 700 feet west of, north of track, on bowlder: point in square marked "U. S. B. M. 7693"	7,692.488
Bailey, in front of station; top of rail	7,729.9
Bailey, 620 feet west of station, 50 feet south of track, 20 feet east of small bridge over Platte River, in granite outcrop; aluminum tablet stamped "7733"	7,732.300

COMO QUADRANGLE.

Bailey west along Colorado & Southern Ry. to Bakers Tank.

	Feet.
Bailey, 1.13 miles west of, on top of bolt in top of northwest bent of bridge 1081; point in square marked "U. S. B. M. 7794"	7,793.2
Glenisle, in front of station; top of rail	7,830.9
Grousemont, in front of station; top of rail	7,925.2
Grousemont, 40 feet west of station, 30 feet north of track, in large bowlder; aluminum tablet stamped "7931"	7,930.200
Maddox, in front of signboard; top of rail	7,989.9
Altruria, in front of signboard; top of rail	8,022.6
Shawnee, in front of station; top of rail	8,065.7
Shawnee, 325 feet west of station, 20 feet south of track, in large bowlder; aluminum tablet stamped "8066"	8,066.1
Boxwood Spur, in front of station sign; top of rail	8,184.6
Boxwood Spur, 0.32 mile west of, north of track, in base of whistle post; spike marked "U. S. B. M. 8206"	8,206.0
Long Meadow, in front of signboard; top of rail	8,239.0
Kline, 40 feet east of station signboard south of track, on rock; point in square marked "U. S. B. M. 8287"	8,286.612
Chase, in front of station; top of rail	8,351.7
Chase, 290 feet west of, 50 feet south of track, in large bowlder; aluminum tablet stamped "8361"	8,360.315
Cassells, 130 feet west of station, at cattle guard, south of track, on rock; point in square marked "U. S. B. M. 8423"	8,422.97
Cassells, in front foundation of Cassells Hotel; aluminum tablet stamped "8445"	8,445.146
Cassells, 1.30 miles west of, north of track, 15 feet south of road, on rock; point in square marked "U. S. B. M. 8505"	8,504.33
Grant, in front of station; top of rail	8,575.0
Grant, 0.18 mile west of, 5 feet north of track, 20 feet south of road, at east end of cut, in bowlder; aluminum tablet stamped "8591"	8,590.444
Grant, 1.52 miles west of, south of track, on rock; point in square marked "U. S. B. M. 8769"	8,768.68
Webster, 0.01 mile west of station, 20 feet south of track, 15 feet west of wooden bridge, in bowlder; aluminum table stamped "9020"	9,019.778
Webster, 0.96 mile west of, 15 feet north of track, 80 feet west of bridge, on rock; point in square marked "U. S. B. M. 9180	9,179.90
Hoosier, 1.17 miles east of, 65 feet east of road crossing, 5 feet north of track, in cut; aluminum tablet stamped "9541"	9,541.016
Hoosier, 1.07 miles west of, 425 feet east of milepost 75, 25 feet south of track, on rock at base of telegraph pole; point in square marked "U. S. B. M. 9843"	9,843.32
Kenosha, in front of station; top of rail	9,990.4
Kenosha, 120 feet east of east corner of station, 100 feet west of north corner of section house, 140 feet north of track, in granite outcrop; aluminum tablet stamped "9992"	9,991.698
Kenosha, 0.85 mile west of, 250 feet west of milepost 77, north of track, on rock; point in square marked "U. S. B. M. 9834" (should be marked "9857")	9,857.09
Kenosha, 2.54 miles west of, 20 feet north of track, 65 feet south of fence, 160 feet west of cattle guard, in bowlder; aluminum tablet stamped "9587"	9,586.826

	Feet.
Jefferson, in front of station; top of rail	9,507.6
Jefferson, northwest corner of front face of schoolhouse; aluminum tablet stamped "9500"	9,499.903
Michigan, 225 feet south of track, in front foundation of C. E. Whitten's ranch house; aluminum tablet stamped "9504"	9,503.803
Michigan, in front of signboard; top of rail	9,514.9
Como, in front of station; top of rail	9,794.9
Como, in front face of railroad hotel, southwest corner; aluminum tablet stamped "9796"	9,796.333
Como, 1.07 miles west of, north of track, on bowlder; point in square marked "U. S. B. M. 9908"	9,908.20
Como, 2.09 miles west of, south of track, on bowlder; point in square marked "U. S. B. M. 9996"	9,996.33
Peabodys, 20 feet west of signboard, 12 feet south of track, in large rock, aluminum tablet stamped "10097"	10,097.587
Peabodys, 1 mile northwest of, west of track, on rock; point in square marked "U. S. B. M. 10284"	10,284.213
Halfway, 0.10 mile west of station, 160 feet east of milepost 94, 15 feet west of old water tank, 15 feet north of track, in granite outcrop; aluminum tablet stamped "10577"	10,577.457
Halfway, 1 mile northwest of, 150 feet north of milepost 95, 15 feet east of track, on rock; point in square marked "U. S. B. M. 10766"	10,765.77
Halfway, 3.22 miles northwest of, 95 feet west of snowshed, 35 feet north of track, 0.14 mile west of milepost 97; aluminum tablet stamped "11176"	11,176.625
Boreas, in front of station; top of rail	11,489.27
Boreas, 350 feet west of station, 65 feet southeast of west end of snowshed, in top of granite bowlder; aluminum tablet stamped "11482"	11,482.786
Farnham, 0.74 mile northwest of, east of track, on bowlder; point in square marked "U. S. B. M. 11133"	11,133.05
Dwyer, in front of signboard; top of rail	11,096.7
Bakers Tank, 0.06 mile northwest of, 115 feet northwest of water tank, 15 feet east of track, in outcrop of red stone; aluminum tablet stamped "10860"	10,860.483
Bakers Tank, 1.06 miles northwest of, 200 feet northwest of sign reading "1 mile to water tank," east of track, on rock; point in square marked "U. S. B. M. 10692"	10,692.38

LEADVILLE QUADRANGLE.

Argentine along Colorado & Southern Ry. to Leadville.

Argentine, in front of signboard; top of rail	10,603.8
Argentine, 0.46 mile northwest of, 160 feet southeast of milepost 104, east of track, on rock; point in square marked "U. S. B. M. 10545"	10,545.10
Pittsburg, in front of signboard; top of rail	10,337.2
Pittsburg, 353 feet northwest of signboard, west of track, on rock; point in square marked "U. S. B. M. 10326"	10,326.51
Washington, 300 feet northwest of signboard, 5 feet north of rail, in granite bowlder; aluminum tablet stamped "10231"	10,231.100
Breckenridge, 3.10 miles southeast of, north of track, on rock; point in square marked "U. S. B. M. 10053"	10,053.60

	Feet.
Breckenridge, 2.13 miles southeast of, north of track, on rock; point in square marked "U. S. B. M. 9883"	9,883.20
Breckenridge, 1.80 miles south of, 350 feet south of track, 150 feet south of siding, east of public road, in large granite bowlder; aluminum tablet stamped "9844"	9,844.537
Puzzle, in front of signboard; top of rail	9,803.8
Breckenridge, in front of station; top of rail	9,564.7
Breckenridge, in front face of H. C. Finding's store; aluminum tablet stamped "9577"	9,577.282
Wheeler, 1.50 miles southwest of, east of track, point on rock marked "U. S. B. M. 10002"	10,001.43
Johnson, in front of signboard; top of rail	10,044.18
Harrison, in front of signboard; top of rail	10,194.8
Harrison, 0.17 mile southwest of, 270 feet north of milepost 129, 400 feet southwest of culvert 1332, 30 feet west of track, in granite bowlder; aluminum tablet stamped "10226"	10,226.133
Wilder, in front of signboard; top of rail	10,258.9
Wilder, 1.25 miles southwest of, east of track, on bowlder; point in square marked "U. S. B. M. 10375"	10,374.56
Kokomo, 0.72 mile north of, east of track, on rock; point in square marked "U. S. B. M. 10494"	10,494.36
Kokomo, 160 feet north of, north end of snowshed, 15 feet east of track, in large granite bowlder; aluminum tablet stamped "10618"	10,618.392
Robinson, in front of signboard; top of rail	10,855.2
Robinson, 0.95 mile south of station, 100 feet west of Colorado & Southern Ry. track, 120 feet east of Denver & Rio Grande R. R. track, 50 feet northwest of miner's abandoned cabin, 15 feet west of old mine shaft, in flat granite bowlder; aluminum tablet stamped "11003"	11,003.114
Buffer, 30 feet north of signboard, 8 feet east of track, on top of granite bowlder; point in square marked "U. S. B. M. 11146"	11,146.15
Buffer, in front of signboard; top of rail	11,148.25
Climax, 100 feet south of signboard, 25 feet east of main track, 8 feet north of telegraph pole, in top of granite bowlder; aluminum tablet stamped "11320"	11,320.195
Climax, 1.06 miles south of, east of track, on rock; point in square marked "U. S. B. M. 11250"	11,249.84
Wortmans, 0.92 mile south of, 45 feet west of culvert 1352, south of track; point on rock marked "U. S. B. M. 11158"	11,158.41
Wortmans, 1.70 miles west of, 310 feet west of milepost 140, north of track; point on rock marked "U. S. B. M. 11082"	11,081.80
Wortmans, 2.65 miles west of, 40 feet west of sign "1 mile to water tank," 50 feet east of milepost 141, 15 feet north of track, in top of granite bowlder; aluminum tablet stamped "10994"	10,994.319
French Gulch, 35 feet north of signboard, in west front stone foundation of water tank; chiseled square marked "U. S. B. M. 10901"	10,900.68
Birdseye, 1.21 miles north of, 1,050 feet north of milepost 143, east of track, south end of cut, on rock; point in square marked "U. S. B. M. 10783"	10,783.42
Birdseye, 40 feet north of signboard, 90 feet east of handcar house, 5 feet north of siding, in large granite bowlder; aluminum tablet stamped "10673"	10,672.902

	Feet.
Birdseye, 0.68 mile south of, 350 feet west of milepost 145, 8 feet south of track; top of large bowlder marked "U. S. B. M. 10611"	10,611.41
Birdseye, 1.67 miles south of, east of track, 125 feet south of milepost 146, 165 feet north of sign "1 mile to water tank;" point on rock marked "U. S. B. M. 10522"	10,522.59
Birdseye, 2.73 miles south of, 300 feet south of milepost 147, in south foundation of water tank; aluminum tablet stamped "10416"	10,416.514
Birdseye, 3.6 miles south of, opposite milepost 148, 3 feet east of track, on rock; point in square marked "U. S. B. M. 10352"	10,352.47
Birdseye, 4.62 miles south of, opposite milepost 149, east of track, on rock; point in square marked "U. S. B. M. 10324"	10,323.81
Leadville, crossing of Colorado & Southern Ry. and Denver & Rio Grande R. R.; no record of mark, probably top of rail	10,235.5
Leadville, in front of Colorado & Southern R. R. station; top of rail	10,207.0
Leadville, southwest corner, front face of post office; aluminum tablet stamped "10153"	10,153.396
Leadville, southeast corner, front face of courthouse; aluminum tablet stamped "10140"	10,140.690

Leadville along Denver & Rio Grande R. R. to Pando.

Leadville, in front of Denver & Rio Grande R. R. station; top of rail	10,184.4
Leadville, 0.65 mile west of Denver & Rio Grande R. R. station, 370 feet east of sign "Leadville 1 mile," north of track, on rock; point in square marked "U. S. B. M. 10101"	10,101.02
Leadville, 1.99 miles west of, 90 feet east of wooden box culvert, 850 feet east of milepost 278, north of track, on rock; point in square marked "U. S. B. M. 9909"	9,909.21
Leadville Junction, in front of station; top of rail	9,744.5
Leadville Junction, 0.28 mile north of, 50 feet south of east end of wooden bridge, 30 feet south of road, 5 feet south of fence, 10 feet east of Tennessee River, in top of granite bowlder; aluminum tablet stamped "9755"	9,755.537
Keeldar, opposite milepost 277, 45 feet west of track, 75 feet northwest of switch stand, south end of siding, east of fence, in granite bowlder; aluminum tablet stamped "9936"	9,936.051
Keeldar, in front of signboard; top of rail	9,958.6
Tennessee Pass, in front of station; top of rail	10,218.8
Tennessee Pass, 430 feet north of station, in north foundation stone of water tank; aluminum tablet stamped "10223"	10,222.788
Mitchell, in front of signboard; top of rail	9,914.6
Mitchell, 915 feet north of signboard, 600 feet south of milepost 284, west of track, in granite bowlder; aluminum tablet stamped "9890"	9,890.112
Mitchell, 3.25 miles north of, 175 feet south of milepost 287, west of track, in face of granite bowlder; aluminum tablet stamped "9415"	9,415.205
Pando, 2.27 miles north of, 80 feet south of milepost 291, in southwest abutment of bridge 290–B over Eagle River; aluminum tablet stamped "9042"	9,042.234

MOUNT POWELL QUADRANGLE.

Bartholomew along Denver & Rio Grande R. R. to Minturn.

	Feet.
Bartholomew, in front of signboard; top of rail	9, 378. 8
Breckenridge, 2.03 miles northwest of, on northwest abutment of steel bridge over river; center of square marked "U. S. B. M. 9534"	9, 354. 08
Braddock, in front of signboard; top of rail	9, 241. 2
Dickey, 340 feet south of station, in front face of stone pump house; aluminum tablet stamped "9009"	9, 008. 786
Dickey, 2.12 miles southwest of, at southeast end of bridge 1324, south bank of creek, on large granite bowlder; point in square marked "U. S. B. M. 9121"	9, 120. 40
Frisco, 45 feet southeast of station, 30 feet east of track, in face of large granite bowlder; aluminum tablet stamped "9097"	9, 096. 777
Frisco, in front of station; top of rail	9, 097. 3
Curtin, in front of signboard; top of rail	9, 295. 9
Curtin, 0.99 mile southwest of, at aerial tramway, 20 feet west of track, 12 feet north of bunk house, in granite bowlder; alluminum tablet stamped "9454"	9, 453. 784
Curtin, 4.12 miles southwest of, 45 feet east of water tank, 5 feet east of track, in granite bowlder; aluminum tablet stamped "9739"	9, 739. 136
Red Cliff, in front of station; top of rail	8, 599. 6
Red Cliff, 160 feet north of station, 40 feet west of platform, 50 feet west of small tool house, 10 feet west of track; aluminum tablet stamped "8598"	8, 598. 224
Rock Creek, 0.22 mile north of, 45 feet north of milepost 297, 15 feet east of track, in face of cut; aluminum tablet stamped "8266"	8, 265. 597
Minturn, 1.95 miles south of, 120 feet south of milepost 300, east of track, in top of concrete culvert; aluminum tablet stamped "7968"	7, 968. 044
Minturn, 0.05 mile south of station, east of track, in northwest corner, front face of section house; aluminum tablet stamped "7819"	7, 818. 865
Minturn, in front of station; top of rail	7, 814. 64
Minturn, 3.98 miles west of, 250 feet east of milepost 306, 20 feet south of track, in top of large granite bowlder; aluminum tablet stamped "7571"	7, 570. 638

EAGLE QUADRANGLE.

Avon along Denver & Rio Grande R. R. to Gypsum.

Avon, in front of station; top of rail	7, 455. 9
Avon, 1.16 miles west of, 550 feet west of milepost 309, north of track, south of fence, in top of granite bowlder; aluminum tablet stamped "7379"	7, 378. 263
Avon, 2.88 miles west of, 900 feet east of milepost 311, 270 feet east of private road crossing to Frank Germon's farm, in top of large granite bowlder; aluminum tablet stamped "7300"	7, 299. 326
Allenton, 80 feet east of signboard, 175 feet north of bridge over Eagle River, 60 feet south of track, in large granite bowlder; aluminum tablet stamped "7135"	7, 134. 475

	Feet.
Allenton, in front of signboard; top of rail	7,135.3
Wolcott, 2.16 miles east of, 525 feet east of milepost 317, 160 feet northeast of northeast corner of wooden bridge over Eagle River, 25 feet south of track, 21 feet north of fence, in top of flat granite rock; aluminum tablet stamped "7041"	7,040.159
Wolcott, 1.06 miles east of, north of track, 120 feet east of milepost 318; point on rock marked "U. S. B. M. 6997"	6,996.00
Wolcott, in front of station; top of rail	6,966.1
Wolcott, 45 feet north of northeast corner of Eagle River Inn fence, 40 feet west of southwest corner of O. E. Smith's blacksmith shop, 100 feet south of southeast corner of wooden bridge over Eagle River, 5 feet east of road, in top of large granite bowlder; aluminum tablet stamped "6955"	6,954.493
Sherwood, 1.68 miles west of, 20 feet west of track, 35 feet west of milepost 323, in top of flat granite bowlder; aluminum tablet stamped "6864"	6,863.514
Ortega, 2.34 miles west of, 310 feet east of milepost 326, 15 feet south of track, 10 feet north of fence, in granite bowlder; aluminum tablet stamped "6718"	6,717.190
Eagle, in front face of northwest corner of Eagle Club building; aluminum tablet stamped "6602"	6,601.242
Eagle, in front of station; top of rail	6,590.0
Eagle, 2.75 miles west of, 250 feet south of track at crossroads, in northwest corner of Mr. Shirley R. Tuck's house; aluminum tablet stamped "6493"	6,491.986
Gypsum, east side of front steps of schoolhouse, on top of third step; aluminum tablet stamped "6334"	6,333.141
Gypsum, 2.16 miles west of, south of track, 80 feet south of milepost 338, 25 feet north of fence, in top of flat granite bowlder; aluminum tablet stamped "6267"	6,266.023

GLENWOOD SPRINGS QUADRANGLE.

Dotsero along Denver & Rio Grande R. R. to New Castle.

Dotsero, 0.7 mile east of. 215 feet west of milepost 342, 90 feet south of track, 3 feet inside of fence, at east end of old wooden gate, in top of small granite bowlder; aluminum tablet stamped "6162"	6,161.465
Dotsero, in front of signboard; top of rail	6,157.6
Dotsero, 1.3 miles west of, 130 feet east of milepost 344, south of track, in face of side rock cut; aluminum tablet stamped "6151"	6,149.860
Shoshone, 3.5 miles east of, 190 feet east of milepost 347, 10 feet north of track, in top of large granite bowlder; aluminum tablet stamped "6132"	6,131.110
Shoshone, 0.5 mile east of, 75 feet west of milepost 350, 75 feet west of west end of tunnel, south of track, in rock cut; aluminum tablet stamped "6118"	6,116.936
Shoshone, in front of station; top of rail	6,109.4
Shoshone, 1.36 miles west of, 675 feet east of milepost 352, in west end of northwest stone abutment of bridge 351-A; aluminum tablet stamped "6057"	6,056.466
Shoshone, 4.52 miles west of, near east end of Grizzly spur, 12 feet north of side track, 275 feet east of milepost 355, in top of granite bowlder; aluminum tablet stamped "5865"	5,863.932

	Feet.
Grizzly, in front of signboard, top of rail	5, 858. 7
Glenwood Springs, 2.2 miles east of, 210 feet west of milepost 358, 20 feet north of track, in top of large granite bowlder; aluminum tablet stamped "5785"	5, 783. 831
Glenwood Springs, 0.91 mile east of, north of track, at west end of tunnel, on rock; point in square marked "U. S. B. M. 5779"	5, 778. 25
Glenwood Springs, 400 feet west of station, 15 feet north of track, top of abutment of highway bridge over Grand River; marked point in square	5, 739. 70
Glenwood Springs, in front of station; top of rail	5, 747. 4
Glenwood Springs, in face of retaining wall at west end of station, 75 feet south of track; aluminum tablet stamped "5751"	5, 750. 416
Glenwood Springs, in face of stone column at main entrance of Colorado Hotel; aluminum tablet stamped "5764"	5, 763. 226
Glenwood Springs, north side of Grand River, 40 feet west of bath house No. 3, in west end of retaining wall of highway; copper plug stamped "$\frac{16}{5728.2}$" (Central Colorado Power Co. bench mark)	5, 740. 379
Glenwood Springs, 2.66 miles west of, 115 feet east of large yellow barn with red roof, in top of northeast corner of railroad culvert; aluminum tablet stamped "5707"	5, 706. 476
Glenwood Springs, 3.75 miles west of, north of trail, at foot of milepost 364; point on rock	5, 688. 36
Chacra, 2.2 miles east of, north of track, 70 feet east of milepost 366, in face of large granite bowlder; aluminum tablet stamped "5654"	5, 652. 927
New Castle, 3.65 miles east of, 80 feet west of milepost 369, north of track, in top of large granite bowlder; aluminum tablet stamped "5613"	5, 611. 819

RIFLE QUADRANGLE.

New Castle along Denver & Rio Grande R. R. to Grand Valley.

New Castle, 1,480 feet east of station, in top of east side of north abutment of Colorado Midland Ry. bridge; bronze tablet stamped "5552"	5, 551. 074
New Castle, in front of station; top of rail (Colorado Midland Ry. track)	5, 551. 0
West New Castle, in front of station sign; top of rail	5, 544. 6

NOTE.—The Colorado Midland Ry. and the Denver & Rio Grande R. R. use the same track from this point west.

New Castle, 2.95 miles west of, 225 feet east of milepost "NC–No. 3," 40 feet north of west end of railroad bridge 2–A, 40 feet north of track, 5 feet east of gate leading to ranch, at corner of fence, in top of rock; aluminum tablet stamped "5542"	5, 541. 777
Silt, in front of station; top of rail	5, 432. 0
Silt, in southeast corner of front face of foundation of section house; aluminum tablet stamped "5434"	5, 432. 669
Silt, 2.24 miles west of, 60 feet west of milepost "NC–No. 9," north of track, 25 feet below tracks, in top of wing wall of arch culvert; aluminum tablet stamped "5394"	5, 392. 819

	Feet.
Rifle, 2.66 miles east of, 12 feet north of track, 0.32 mile west of milepost "NC–No. 11," in top of concrete railroad culvert; aluminum tablet stamped "5362"	5,361.159
Rifle, in front of station; top of rail	5,299.3
Rifle, 35 feet north of west end of Denver & Rio Grande R. R. station, in top of concrete manhole at margin of highway; aluminum tablet stamped "5302"	5,300.876
Rifle, 3.11 miles west of, 575 feet west of milepost "NC–No. 17," 155 feet west of railroad bridge 17–A, 10.3 feet north of north rail, in top of small bowlder; aluminum tablet stamped "5263"	5,261.659
Lacy, 1.2 miles west of, 40 feet north of milepost "NC–No. 20," 50 feet north of track, at south margin of fence, in top of sandstone rock; aluminum tablet stamped "5214"	5,212.831
Morris, in front of station; top of rail	5,203.5
Morris, 0.5 mile west of, 30 feet north of tracks, 25 feet south of fence, 215 feet east of small log cabin, in top of large granite bowlder; aluminum tablet stamped "5202"	5,200.661
Grand Valley, 6.07 miles east of, 1,115 feet west of milepost "NC–No. 25," 11.5 feet north of track, in center of coping stone of railroad culvert; aluminum tablet stamped "5165"	5,163.653

CAMEO QUADRANGLE.

Grand Valley along Denver & Rio Grande R. R. to Grand Junction.

Grand Valley, 2.25 miles east of, 235 feet west of milepost "NC–No. 29," 30 feet south of track, 20 feet north of fence, 185 feet east of railroad bridge 29–A, in top of granite bowlder; aluminum tablet stamped "5118"	5,117.372
Grand Valley, 2 miles east of, 12 feet north of track, in top of foundation of pillar of water tank; bronze tablet stamped "5095"	5,094.405
Grand Valley, in front of station; top of rail	5,094.0
Grand Valley, 2.4 miles west of, north of west end of railroad bridge 33–B, in top of flat granite bowlder; aluminum tablet stamped "5031"	5,030.260
Una, in front of station; top of rail	5,015.6
Una, 1 mile west of, opposite milepost "NC–No. 37," 55 feet south of track, 50 feet north of fence, in top of granite bowlder; aluminum tablet stamped "5024"	5,022.756
De Beque, 2.78 miles east of, 360 feet west of milepost "NC–No. 41," 40 feet south of track, in top of sandstone rock; aluminum tablet stamped "4962"	4,961.401
De Beque, in front of station; top of rail	4,935.1
De Beque, 3.11 miles west of, 200 feet west of milepost "NC–No. 47," in top of stone culvert; aluminum tablet stamped "4959"	4,957.792
Akin, 0.1 mile west of, 85 feet northeast of milepost "NC–No. 51," 75 feet north of main track, in face of large granite bowlder; aluminum tablet stamped "4835"	4,833.998
Akin, 2.1 miles west of, 110 feet east of milepost "NC–No. 53," 35 feet south of track on bank of river, in top of granite bowlder; aluminum tablet stamped "4833"	4,831.998
Tunnel, in front of station; top of rail	4,807.9

	Feet.
Tunnel, 1 mile west of, 80 feet west of west end of tunnel, 30 feet west of milepost "NC–No. 56," 6 feet north of track, in top of bottom foundation stone of old water tank; aluminum tablet stamped "4794"	4,793.291
Tunnel, 4 miles west of, 20 feet east of milepost "NC–No. 59," 12 feet north of track, in face of granite bowlder; aluminum tablet stamped "4773"	4,772.005
Palisade, 2.41 miles east of, 138 feet west of milepost "NC–No. 62," 20 feet north of track, in top of large bowlder; aluminum tablet stamped "4742"	4,741.449
Palisade, in front of station; top of rail	4,731.2
Palisade, in front face of southwest corner of main entrance to Jordan Inn; aluminum tablet stamped "4729"	4,727.709
Palisade, 3.95 miles west of, 0.45 mile west of milepost "NC–No. 68," 268 feet east of road crossing, 15 feet south of track, in top of railroad culvert; aluminum tablet stamped "4709"	4,708.058
Clifton, 1.11 miles west of, 600 feet west of milepost "NC–No. 71," north of track, in top of parapet wall around iron pipe; aluminum tablet stamped "4685"	4,684.584
Fruitvale, in front of signboard; top of rail	4,652.7

GRAND JUNCTION QUADRANGLE.

Grand Junction along Denver & Rio Grande R. R. to Whitewater.

Grand Junction, 2.29 miles east of, on Teller Institute grounds, in west face of north end of brick barn; aluminum tablet stamped "4598"	4,597.478
Grand Junction, in front of station; top of rail	4,574.6
Grand Junction, at station, in front face of baggage room; aluminum tablet stamped "4579"	4,577.943
Grand Junction, in front face of southeast corner of Grand Valley National Bank; aluminum tablet stamped "4587"	4,586.525
Grand Junction, north side of Carnegie Library building; iron post stamped "4606.2" (Reclamation Service bench mark)	4,595.513
Grand Junction, 1.3 miles southeast of, 312 feet southeast of milepost "D–423," 20 feet north of railroad bridge 422–A, on rock; point in square marked "U. S. B. M."	4,567.28
Grand Junction, 3.22 miles southeast of, 40 feet southeast of mile post "D–421," 12 feet south of track, in top of granite bowlder; aluminum tablet stamped "4587"	4,586.139
Grand Junction, 6.25 miles southeast of, 315 feet southeast of milepost "D–418," 50 feet east of track, in top of granite bowlder; aluminum tablet stamped "4612"	4,610.635
Unaweep, in front of signboard; top of rail	4,615.8
Grand Junction, 9.16 miles southeast of, 70 feet northwest of milepost "D–415," west of track, in top of granite bowlder; aluminum tablet stamped "4625"	4,623.936

DELTA QUADRANGLE.

Whitewater along Denver & Rio Grande R. R. to Chipeta.

Whitewater, in front of station; top of rail	4,644.5
Whitewater, 25 feet southeast of east end of bridge; iron post stamped "4643"	4,643.197

	Feet.
Whitewater, 1.41 miles southeast of, 80 feet southeast of milepost "D–410," east of track, on rock; point in square marked "U. S. B. M. 4660"	4, 658. 64
Whitewater, 2.38 miles southeast of, 75 feet north of milepost "D–409," 55 feet east of track, in top of large rock; aluminum tablet stamped "4662"	4, 661. 121
Kahnah, 1.96 miles southeast of, 125 feet southeast of milepost "D–406," 20 feet east of track, in top of large rock; aluminum tablet stamped "4675"	4, 674. 220
Deer Run, 0.9 mile southeast of, 45 feet west of milepost "D–402," 30 feet west of track, in top of large rock; aluminum tablet stamped "4694"	4, 692. 980
Deer Run, 3.89 miles southeast of, 200 feet southeast of milepost "D–399," east of track, in top of granite bowlder; aluminum tablet stamped "4722"	4, 721. 142
Bridgeport, 0.32 mile northwest of, 145 feet southeast of milepost "D–398," 20 feet east of track, on rock; point in square marked "U. S. B. M. 4735"	4, 733. 83
Bridgeport, 1.61 miles southeast of, 90 feet east of milepost "D–396," 10 feet north of track, in top of granite bowlder; aluminum tablet stamped "4750"	4, 749. 104
Dominguez, 1.95 miles northwest of, 115 feet northeast of milepost "D–393," 144 feet southeast of road crossing, 10 feet east of track, in top of granite bowlder; aluminum tablet stamped "4770"	4, 768. 851
Dominguez, 50 feet east of milepost "D–391," 250 feet south of water tank; iron post stamped "4,788.4" (Reclamation Service bench mark)	4, 777. 715
Dominguez, 3.05 miles southeast of, 95 feet southeast of milepost "D–388," 32 feet south of track, in top of granite bowlder; aluminum tablet stamped "4806"	4, 804. 977
Escalante, 0.18 mile northwest of, 515 feet west of milepost "D–385," 50 feet north of track, 950 feet west of Escalante siding, in top of granite bowlder; aluminum tablet stamped "4826"	4, 825. 520
Escalante, 2.93 miles southeast of, 85 feet south of milepost "D–382," 12 feet east of track, in top of granite bowlder; aluminum tablet stamped "4847"	4, 845. 725
Stratter, in front of signboard; top of rail	4, 859. 7
Roubideau, 0.44 mile northwest of, east of track, 40 feet south of milepost "D–378," on rock, point in square marked "U.S.B.M. 4874"	4, 873. 20
Roubideau, 25 feet north of track, opposite stock yard, 16 feet west of telephone box; iron post stamped "4903" (Reclamation Service bench mark)	4, 882. 41
Delta, 2.41 miles northwest of, 1,100 feet northwest of milepost "D–375," at south end of bridge; in top of east stone abutment; aluminum tablet stamped "4913"	4, 912. 638
Delta, 3 feet east of front of courthouse; iron post stamped "4974" (Reclamation Service bench mark)	4, 953. 762
Delta, in front of station; top of rail	4, 960. 37
Delta, 3.22 miles southeast of, 5 feet southeast of telephone pole 1855, 100 feet east of track, 18 telegraph poles north of white schoolhouse; iron post stamped "5102" (Reclamation Service bench mark)	5, 081. 801

	Feet.
Chipeta, in front of signboard; top of rail	5,151.5
Chipeta, 1 mile southeast of, 190 feet south of road crossing, in top of north end of retaining wall of railroad culvert; aluminum tablet stamped "5191"	5,190.769

HOTCHKISS QUADRANGLE.

Chipeta along Denver & Rio Grande R. R. to Montrose.

Chipeta, 2.06 miles southeast of, 5 feet south of telegraph pole 2028, 80 feet from track near culvert 365-A; iron post stamped "5250" (Reclamation Service bench mark)	5,230.348
Olathe, in front of station; top of rail	5,346.20
Olathe, 90 feet east of main track, in front of station, in line between telegraph poles 2161 and 2163; iron post stamped "5368" (Reclamation Service bench mark)	5,348.439
Frosts, in front of signboard; top of rail	5,446.2
Frosts, 69 feet south of signboard, south of road to dwelling, 12 feet west of ditch; iron post stamped "5464" (Reclamation Service bench mark)	5,444.256
Montrose, 4.96 miles northwest of, 45 feet east of railroad at crossing, north of road, in line with railroad fence, 1,860 feet north of schoolhouse; iron post stamped "5592" (Reclamation Service bench mark)	5,574.521

MONTROSE QUADRANGLE.

Montrose along Denver & Rio Grande R. R. to Ridgway.

Montrose, 2.19 miles northwest of, 1,350 feet south of milepost "D-354," 300 feet south of railroad crossing, 40 feet east of tracks, 7 feet southeast of telegraph pole; iron post stamped "5722" (Reclamation Service bench mark)	5,702.177
Montrose, in front of station; top of rail	5,794.2
Montrose, northwest corner of Coor's building opposite station, at corner of sidewalk, flush with ground; iron post (Reclamation Service bench mark)	5,793.834
Montrose, 3.17 miles south of, 50 feet southeast of cattle guard just south of Chief Ouray's homestead, 45 feet east of track; iron post stamped "5945" (Reclamation Service bench mark)	5,925.363
Montrose, 4.70 miles south of, near brick schoolhouse, 43 feet south of telephone pole 2837, 1,015 feet south of milepost "D-356," at road crossing, 30 feet east of track; iron post stamped "6017" (Reclamation Service bench mark)	5,997.021
Uncompahgre, in front of signboard; top of rail	6,165.9
Uncompahgre, 55 feet southeast of corner of Fenlon's store, 4 feet northwest of telephone pole 2978 marked "Montrose, 8.5 miles," at west margin of road; iron post stamped "6184" (Reclamation Service bench mark)	6,164.100
Uncompahgre, 1.92 miles southeast of, in front face of southwest corner of foundation to Jutten's school; aluminum tablet stamped "6261"	6,260.254
Colona, in front face of northeast corner of Odd Fellows Hall; aluminum tablet stamped "6387"	6,386.174

	Feet.
Colona, in front of signboard; top of rail	6,391.6
Eldredge, in front of signboard; top of rail	6,524.7
Eldredge, 0.53 mile southeast of, 150 feet south of milepost "D–368," 40 feet west of track, in top of large granite bowlder; aluminum tablet stamped "6554"	6,553.301
Eldredge, 3.14 miles southeast of, 1,875 feet north of milepost "D–371," in foundation of water tank; aluminum tablet stamped "6677"	6,676.815
Ridgway, 2.77 miles north of 105 feet south of north end of switch, 40 feet west of sidetrack, in top of 3 by 2.5 by 2.5 foot stone pier; aluminum tablet stamped "6910"	6,910.282
Ridgway, in front of station; top of rail	6,985.3
Ridgway, 17 feet southeast of station; iron post marked "6990 OURAY"	6,986.543

PRIMARY LEVELING.

Denver, Greeley, Loveland, and Niwot quadrangles.

ARAPAHOE, BOULDER, AND WELD COUNTIES.

The elevations in the following list are based on the elevation of the top of the lower pedestal at the southeast corner of the steps of the Colorado State capitol, at Denver. The point is marked by the letters "U.S.B.M." cut in the top of a granite block. The elevation is obtained from the Coast and Geodetic Survey transcontinental line of leveling, and is now accepted as 5,278.255 feet, according to approximate adjustment in 1911.

Leveling was done in all four quadrangles in 1897 by Thomas Winsor, and in 1899 by E. W. Glafcke and A. E. Franklin. Additional work was done in the Loveland and Niwot quadrangles in 1902 by F. M. Taylor.

DENVER QUADRANGLE.

Bench marks established at Denver.

NOTE.—The first five elevations result directly from precise leveling of the Coast and Geodetic Survey, as described in their report for 1903, Appendix No. 3. The tablets were set by the United States Geological Survey.

	Feet.
Denver, east front of State capitol; lower pedestal, southeast corner of steps; "U. S. B. M." cut on top of granite block	5,278.255
Denver, southeast corner of State capitol grounds, azimuth station near steps, in top of stone post; aluminum tablet stamped "5275 DENVER"	5,278.095
Denver, in steps at northeast corner of State capitol grounds; bronze tablet (also used as azimuth mark), stamped "5275 DENVER"	5,277.285
Denver, chamber of commerce building, in granite block directly above corner stone, 4.5 feet above sidewalk; bronze tablet stamped "5224"	5,222.752

	Feet.
Denver, east front of union station, north side of main entrance, 2 feet above pavement; bronze tablet stamped "5184 DENVER"	5,186.598
Denver, east front of union station; cross in floor of main entrance, city datum	5,184.57
Denver, South Broadway, southwest of Colorado & Southern Ry. track, 4 feet north of electric pole of Denver Tramway Co.; iron post stamped "5258 DENVER"	5,260.573
T. 4 S., R. 67 W., sec. 1, 500 feet northwest of Glendale dairy, 3 feet west of a corner stone, at fence corner on southwest side of Cherry Creek road; iron post stamped "5359 DENVER"	5,361.507

Denver north along Union Pacific R. R. to Brighton.

NOTE.—The bench marks on this line were set by the United States Geological Survey, but the elevations are those determined by the line afterwards run by the Coast and Geodetic Survey.

T. 3 S., R. 67 W., sec. 6, Hotel Model, 18 feet northwest of track, on north side of highway; iron post stamped "5131 DENVER"	5,133.437
Hazeltine, 1.2 miles southwest of, sec. 16, T. 2 S., R. 67 W., 41 feet northwest of track, on north side of highway, 200 yards north of mileboard 10; iron post stamped "5090 DENVER"	5,093.67
Henderson, 0.5 mile northwest of, sec. 35, T. 1 S., R. 67 W., 196 feet northwest of main track, on north side of highway; iron post stamped "5034 DENVER"	5,035.799
T. 1 S., R. 67 W., sec. 13, schoolhouse 10, Arapahoe County, 23 feet west of track, on north side of highway, 22 miles south of Greeley; iron post stamped "5005 DENVER"	5,007.708
Brighton, 1 mile north of, 24 feet west of track, on south side of highway known as "base-line road"; iron post stamped "4966 DENVER"	4,967.622

Denver along Union Pacific R. R. via Magnolia to Watkins.

NOTE.—These bench marks were set by the Geological Survey, but all except the second one have been touched upon by precise levels of the Coast and Geodetic Survey, and the elevations given herewith are the same as determined by that survey.

Denver, 6.4 miles east of, 0.2 mile south of Sand Creek slaughterhouse, 14 feet south of main track; iron post stamped "5275 DENVER"	5,277.737
T. 2 S., R. 67 W., 41 feet northwest of southeast corner of sec. 33, 1.7 miles east of the intersection of south township line with Chicago, Burlington & Quincy R. R.; iron post stamped "5182 DENVER"	5,184.604
Magnolia, 0.2 mile east of, sec. 25, T. 3 S., R. 67 W., 40 feet north of track; iron post stamped "5333 DENVER"	5,335.680
T. 3 S., R. 66 W., 0.2 mile south of Grippen's ranch, 100 feet north of track; iron post stamped "5400 DENVER"	5,402.583
T. 3 S., R. 66 W., sec. 36, 1.1 miles southeast of Behren's ranch, 50 feet south of track, 60 feet east of bridge 803; iron post stamped "5484 DENVER"	5,486.712
Watkins, 0.2 mile east of, sec. 36, T. 3 S., R. 65 W., 180 feet north of track; iron post stamped "5513 DENVER"	5,515.503

Watkins north to sec. 36, T. 1 S., R. 65 W.

	Feet.
T. 2 S., R. 65 W., 9 feet north and 3 feet east of southwest corner of sec. 36; iron post stamped "5399 DENVER"	5, 401. 409
T. 2 S., R. 64 W., northwest corner of sec. 30, 0.5 mile north of Creutz's ranch, 42 feet southeast of intersection of forks of roads; iron post stamped "5279 DENVER"	5, 281. 419
T. 1 S., R. 65 W., 27 feet north of southwest corner of sec. 36, 1.3 miles northwest of Wellenkotter's ranch; iron post stamped "5206 DENVER"	5, 208. 205

Denver along Chicago, Burlington & Quincy R. R. to Erie.

Denver, 3.5 miles north of. 200 yards southeast of Utah Junction, sec. 15, T. 3 S., R. 68 W., 64 feet west of track; iron post stamped "5219 DENVER"	5, 221. 552
Harris, 0.2 mile south of, sec. 6, T. 3 S., R. 68 W., 38 feet southwest of Union Pacific R. R.; iron post stamped "5293 DENVER"	5, 295. 494
Semper, 0.2 mile north of, 22 feet east of Union Pacific R. R. track, 350 feet west of Semper schoolhouse, on north side of public highway; iron post stamped "5438 DENVER"	5, 440. 430
Churches, sec. 11, T. 2 S., R. 69 W., 31 feet southeast of Union Pacific R. R., on east side of public highway; iron post stamped "5331 DENVER"	5, 333. 427
Burns Junction, 0.2 mile northwest of, sec. 34, T. 1 S., R. 69 W., 82 feet northeast of track, north side of public highway; iron post stamped "5413 DENVER"	5, 415. 451
Clarkston, sec. 23, T. 1 S., R. 69 W., 32 feet east of main track. north side of public highway, 700 feet east of northwest corner of section; iron post stamped "5214 DENVER"	5, 216. 339

Golden to Denver Edgewater.[1]

Golden, entrance to the Woods-Rubey National Bank, top of stone steps; aluminum tablet stamped "5675 DENVER"	5, 674. 709
Gear farmhouse, 180 feet east of gate, 50 feet northeast of wagon bridge across Rocky Mountain irrigating ditch, 15 feet north of road; iron post stamped "5560 DENVER"	5, 559. 880
Kirk's farmhouse, 90 feet east of gate, northwest corner of cross-roads; iron post stamped "5575 DENVER"	5, 574. 765
Denver Edgewater, southwest corner of Highland Avenue and Sheridan Boulevard, in foundation southeast corner of Edgewater grocery; aluminum tablet stamped "5353 DENVER"	5, 353. 373

Golden via Coal Creek to summit of Dory Hill divide.

Golden Pressed Brick Co.'s plant, 1.8 miles north of, at road fork, west side of road, in top of granite bowlder; aluminum tablet stamped "5932 DENVER"	5, 931. 567
Mesa between Ralston and Lyden creeks, 0.8 mile north of Ralston Creek bridge, 20 feet west of Golden-Coal Creek road, in top of sandstone ledge; aluminum tablet stamped "6008 DENVER"	6, 007. 321

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[1] The error distributed in this line is excessive.

GREELEY QUADRANGLE.

Brighton north along Union Pacific R. R. to Greeley.

	Feet.
T. 1 N., R. 66 W., sec. 17, 200 yards west of Bryan's ranch, 40 feet west of track, on north side of public highway; iron post stamped "4936 DENVER"	4,937.593
Fort Lupton, northeast corner of schoolhouse grounds, sec. 5, T. 1 N., R. 66 W., 190 feet west of track; iron post stamped "4904 DENVER"	4,905.567
T. 2 N., R. 66 W., sec. 20, 0.2 mile east of Knowlton's ranch, 26 feet west of track, on south side of public highway; iron post stamped "4869 DENVER"	4,870.517
T. 2 N., R. 66 W., sec. 6, 0.2 mile west of Cheese's ranch, 31 feet west of track, on south side of public highway, 300 feet east of main road between Platteville and Fort Lupton, 60 feet south of mileboard 32; iron post stamped "4837 DENVER"	4,838.423
Platteville, 0.5 mile south of, sec. 19, T. 3 N., R. 66 W., 30 feet west of track; iron post stamped "4819 DENVER"	4,820.400
T. 3 N., R. 66 W., sec. 6, 0.2 mile south of Moehrle's ranch, 36 feet west of track, north side of public highway, 2.2 miles north of Platteville; iron post stamped "4795 DENVER"	4,796.350
T. 4 N., R. 66 W., 0.2 mile east of northwest corner of sec. 23, 0.2 mile northeast of Lucerne's ranch, 20 feet west of track, south side of public highway; iron post stamped "4724 DENVER"	4,725.367
La Salle, 0.8 mile north of, sec. 32, T. 5 N., R. 65 W., 60 feet west of track, 200 feet south of old Pikes Peak road; iron post stamped "4650 DENVER"	4,651.355
Greeley, 9 feet north of south line of Tenth Street, 17 feet west of most westerly track, 12 feet south of warning signpost; iron post stamped "4651 DENVER"	4,652.291

Sec. 36, T. 1 S., R. 65 W. north to sec. 28, T. 5 N., R. 65 W.

T. 1 N., R. 65 W., at quarter corner on south side of sec. 35, 200 yards north of Mooney's ranch, 27 feet north of forks of roads; iron post stamped "5098 DENVER"	5,099.907
T. 2 N., R. 65 W., sec. 36, 53 feet northwest of Chicago, Burlington & Quincy R. R. track, 106 feet southwest of face of west abutment of bridge across Boxelder Creek, 2.6 miles northeast of Hudson station; iron post stamped "4918 DENVER"	4,920.035
Boxelder Creek, 200 yards west of, 200 yards south of Oster's ranch, 36 feet southwest of intersecting crossroads; iron post stamped "4851 DENVER"	4,852.770
T. 3 N., R. 65 W., sec. 36, 0.8 mile south of school 41, Weld County, 36 feet west of east range line; iron post stamped "4817 DENVER"	4,818.884
T. 3 N., R. 64 W., southeast corner of sec. 18, 44 feet southwest of an old well, 3 feet east of fence corner; iron post stamped "4807 DENVER"	4,808.713
T. 3 N., R. 65 W., northwest corner of sec. 1, 14 feet south and 3 feet east of fence; iron post stamped "4817 DENVER"	4,818.677
T. 4 N., R. 65 W., 50 feet north of crossroads at southwest corner of sec. 14, 320 feet east of schoolhouse 5; iron post stamped "4693 DENVER"	4,694.590

	Feet.
T. 5 N., R. 65 W., southeast corner of sec. 28, 0.5 mile north of Luper's ranch, 38 feet northwest of forks of road; iron post stamped "4656 DENVER"	4,657.470

At Lafayette.

Lafayette, 0.2 mile north of station, sec. 35, T. 1 N., R. 69 W., 20 feet east of track, north side of public highway known as Base Line road; iron post stamped "5174 DENVER"	5,176,382

St. Vrain along Union Pacific R. R. to Dry Creek.

St. Vrain, 800 feet west of, 35 feet northeast of intersection of Union Pacific R. R. with wagon road; iron post stamped "5119 DENVER"	5,118.246
Dick, about 850 feet west of, 42 feet northeast of intersection of Union Pacific R. R. with wagon road; iron post stamped "5130 DENVER"	5,129.104
Dry Creek, 1 mile east of, 53 feet south of Union Pacific R. R., near wagon road; iron post stamped "5046 DENVER"	5,044.119

Erie via public roads north to Windsor.

T. 2 N., R. 68 W., 4 feet north of southeast corner of sec. 33, 1 mile north of White House coal mine, 30 feet north of forks of roads; iron post stamped "5015 DENVER"	5,014.195
Rinn, 0.5 mile south of post office, southeast corner of sec. 15, T. 2 N., R. 68 W., 45 feet northeast of crossroads; iron post stamped "4882 DENVER"	4,881.114
T. 2 N., R. 67 W., southwest corner of sec. 18, 0.8 mile northwest of Ely coal mine, 60 feet east of fence corner; iron post stamped "4913 DENVER"	4,912.111
Scott's ranch, 100 yards south of, northwest corner of sec. 6, T. 2 N., R. 67 W., 45 feet southeast of intersection of crossroads; iron post stamped "4814 DENVER"	4,813.096
T. 3 N., R. 67 W., northeast corner of sec. 19, 125 feet east of school 28, Weld County, 30 feet southeast of forks of road; iron post stamped "4881 DENVER"	4,880.044
T. 3 N., R. 68 W., southeast corner of sec. 10, 1 mile southeast of Archer's ranch, 44 feet northwest of intersection of roads; iron post stamped "4949 DENVER"	4,947.991
T. 3 N., R. 68 W., at northeast corner of sec. 3, 0.2 mile north of Woodley's ranch, 44 feet southeast of intersection of crossroads; iron post stamped "5086 DENVER"	5,084.934
T. 3 N., R. 67 W., northeast corner of sec. 6, 1 mile south of Hills Lake, 45 feet southeast of intersection of crossroads; iron post stamped "4929 DENVER"	4,927.826
T. 4 N., R. 67 W., northeast corner of sec. 19, 200 feet east of Davis's ranch, 50 feet southeast of intersection of crossroads; iron post stamped "4835 DENVER"	4,833.895
T. 4 N., R. 68 W., northwest corner of sec. 22, 1 mile south of Sunnyside schoolhouse, district 36, Weld County, 45 feet southeast of intersection of crossroads; iron post stamped "4904 DENVER"	4,902.779
T. 4 N., R. 68 W., northwest corner of sec. 3, 0.5 mile west of Twin Mound schoolhouse, district 38, Weld County, 35 feet southwest of forks of road; iron post stamped "5101 DENVER"	5,099.666

	Feet.
T. 4 N., R. 67 W., northeast corner of sec. 6, 0.8 mile north of Dilly Chapel, 45 feet southeast of forks of road; iron post stamped "4887 DENVER"	4,885.728
T. 5 N., R. 67 W., northwest corner of sec. 19, 0.8 mile south of Dells ranch, 45 feet southeast of intersection of forks of roads; iron post stamped "4878 DENVER"	4,876.642
T. 5 N., R 68 W., southeast corner of sec 10, 200 feet west of Spear's ranch, on northeast side of public highway, 30 feet west of fence corner; iron post stamped "4947 DENVER"	4,945.674
T. 5 N., R. 68 W., sec. 3, 1.2 miles north of Boyd Lake, 30 feet south of fence corner; iron post stamped "5015 DENVER"	5,013.638
T. 5 N., R. 67 W., northeast corner of sec. 5, 1 mile north of schoolhouse 22, Weld County, 106 feet southeast of stone; iron post stamped "4921 DENVER"	4,919.539
New Windsor, 500 feet east of station, T. 6 N., R. 67 W., 35 feet southwest of Colorado & Southern Ry. track, on north side of public highway; iron post stamped "4795 DENVER"	4,793.565

Windsor to Greeley.

T. 6 N., R. 67 W., sec. 25, 0.2 mile west of Rawlinson's ranch, 27 feet south of Colorado & Southern Ry. track, on east side of public highway; iron post stamped "4748 DENVER"	4,746.527
Farmers, 500 feet west of, T. 6 N., R. 66 W., 46 feet southwest of Colorado & Southern Ry. track, south side of public road; iron post stamped "4712 DENVER"	4,710.526
Boyds, 500 feet southeast of, southeast corner of sec. 35, T. 6 N., R. 66 W., 100 feet northwest of intersection of crossroads, 250 feet south of Union Pacific R. R.; iron post stamped "4672 DENVER"	4,670.578
Greeley, east front of Weld County courthouse, on north side of main entrance, on stone coping; bronze tablet stamped "4464 DENVER"	4,662.547

Farmers south and east to Union Pacific R. R.

T. 5 N., R. 66 W., sec. 3, 0.5 mile north of Haymaker's ranch, 5 feet west of fence corner, at forks of roads; iron post stamped "4836 DENVER"	4,834.537
T. 5 N., R. 66 W., quarter corner on south side of sec. 21, 150 feet north of schoolhouse, district 24, Weld County, 50 feet northwest of intersection of crossroads; iron post stamped "4830 DENVER"	4,828.496
T. 4 N., R. 66 W., sec. 2, 0.2 mile south of Dunbar's ranch, 30 feet north of forks of roads; iron post stamped "4675 DENVER"	4,673.609

Greeley via Lucerne and Kersey to Greeley.

T. 6 N., R. 65 W., quarter corner on west side of sec. 29, 200 feet southwest of Henry's ranch house; iron post stamped "4718 DENVER"	4,716.067
Lucerne, southwest corner of sec. 17, T. 6 N., R. 65 W., sixth principal meridian, in brick church, in stone foundation of west wall; aluminum tablet stamped "4749 DENVER." (Elevation by Coast and Geodetic Survey)	4,746.575

	Feet.
T. 6 N., R. 65 W., southwest corner of sec. 13, 150 feet south of Hilton's ranch house, at base of northeast fence post; iron post stamped "4700 DENVER"	4,698.366
T. 6 N., R. 64 W., northeast corner of sec. 20, 7 miles east of Lucerne; iron post stamped "4784 DENVER"	4,782.331
T. 5 N., R. 64 W., quarter corner on east side of sec. 5, at base of southwest fence post; iron post stamped "4628 DENVER"	4,625.803
T. 5 N., R. 64 W., southeast corner of sec. 17, 0.5 mile north of Kersey, at base of northwest fence post; iron post stamped "4616 DENVER"	4,613.896
Greeley, 2.8 miles east of, 0.8 mile east of cemetery, 25 feet north of road to Kersey; iron post stamped "4643 DENVER"	4,641.213

Kersey to sec. 13, T. 3 N., R. 65 W.

T. 4 N., R. 64 W., 7 miles south of Kersey, 5 miles north of J. P. Klug's ranch, 8 feet west of road; iron post stamped "4642 DENVER"	4,639.893
T. 4 N., R. 64 W., J. P. Klug's ranch, 25 feet north of fence, west of road, on big flat; iron post stamped "4682 DENVER"	4,680.090
T. 3 N., R. 64 W., northwest corner of sec. 10, southeast corner of fence around J. P. Klug's house; iron post stamped "4730 DENVER"	4,727.990
J. P. Klug's ranch, 4 miles north of, north side of fence, 4 feet east of gate; iron post stamped "4906 DENVER"	4,904.876
T. 2 N., R. 64 W., north edge of, 0.2 mile north of Herman Lewis's ranch, at forks of road; iron post stamped "4880 DENVER"	4,878.166

Boxelder Creek to T. 1 N., R. 64 W., sixth principal meridian.

Boxelder Creek, 2.4 miles east of, 92 feet north of Chicago, Burlington & Quincy R. R., at northeast corner of right of way fence; iron post stamped "4984 DENVER"	4,983.018
Early ranch, 0.8 mile southeast of, just north of fence running west and 450 feet west of the southeast corner of fence around pasture; iron post stamped "4978 DENVER"	4,977.305
Early ranch, 3 miles southeast of, on northeast slope of divide, 300 yards southeast of gulch; iron post stamped "5083 DENVER"	5,081.846

NIWOT QUADRANGLE.

At Mitchell.

Mitchell, 0.5 mile south of, sec. 30, T. 1 N., R. 68 W., 6 feet north of a telegraph pole near the edge of wagon road; iron post stamped "5084 DENVER"	5,086.290

Point near Erie.

Erie, 1 mile northeast of, sec. 7, T. 1 N., R. 68 W., 35 feet north of Union Pacific R. R. track, opposite where wagon road leads southeast to Boulder Valley coal mine; iron post stamped "5076 DENVER"	5,075.197

Point near Berthoud along Colorado & Southern Ry. to Longmont.

Longmont, 3.5 miles north of, 0.2 mile north of Garret Clawson's farm, northwest corner, at crossing of highways; iron post stamped "5126 DENVER"	5,124.121

Feet.

Longmont, 1 mile north of, 15 feet west of southwest corner of sec. 35. T. 3 N., R. 69 W., 200 yards north of cemetery; iron post stamped "5006 DENVER" ---------- 5,004.193

Longmont, T. 2 N., R. 69 W., sec. 2, in northeast corner of city hall; aluminum tablet stamped "4980 DENVER" ---------- 4,978.259

Longmont along Colorado & Southern Ry. via Boulder to Erie.

T 2 N., R. 69 W., sec. 20, 250 yards south of Williamsen's farm, northeast corner of road crossing, cattle guard 15 feet east of center of tracks; iron post stamped "5034 DENVER" ---------- 5,032.948

Niwot, 150 feet west of station, 200 yards east of Niwot Hall, southwest of highway; iron post stamped "5096 DENVER" ---------- 5,094.348

T. 2 N., R 70 W., 30 feet southwest of northeast corner of sec. 33, 0.5 mile south of Haystack Mountain, at southwest corner of crossroads; iron post stamped "5242 DENVER" ---------- 5,240.273

T. 1 N., R. 70 W., sec. 9, 0.8 mile southwest of Beasley's reservoir, west side of highway, in front of Josinas farmhouse; iron post stamped "5236 DENVER" ---------- 5,234.535

T. 1 N., R. 69 W., sec. 19, 0.33 mile west of Lewis's farm, at right angle, north side of highway, at fence; iron post stamped "5103 DENVER" ---------- 5,101.588

Canfield, 100 yards west of station, 100 feet north of railroad tracks, at fence corner; iron post stamped "5047 DENVER" ---------- 5,045.551

Erie, northeast corner of Wells and Pierce streets, southwest front corner of Richards's brick block; aluminum tablet stamped "5018 DENVER" ---------- 5,016.788

Lyons via Hygiene to Longmont.

Lyons, 3 miles east of, south side of road, opposite house of Elias Whaley, beside telephone pole; iron post stamped "5207 DENV" - 5,205.395

Longmont, 3 miles west of, north side of road, at corner of yard fence, in front of Mr. Hill's house; iron post stamped "5091 DENV" ---------- 5,089.442

LOVELAND QUADRANGLE.

New Windsor to Loveland.

T. 6 N., R. 68 W., 250 yards east of bridge over Cache la Poudre Creek on north side of road; iron post stamped "4800 DENVER" - 4,798.102

T. 6 N., R. 69 W., sec. 14, 0.2 mile northwest of Benson's Lake, 100 yards south of C. S. Bate's farmhouse, on west side of road between Loveland and Fort Collins; iron post stamped "5040 DENVER" ---------- 5,038.214

T. 6 N., R. 69 W., 10 feet south of north line of sec. 32, 0.5 mile west of Proctor schoolhouse, 20 feet east from center of Colorado & Southern Ry. tracks south side of highway; iron post stamped "5057 DENVER" ---------- 5,055.114

Loveland, 2 miles north of, 10 feet north of south line of sec. 2, T. 5 N., R. 69 W., 40 feet east of center of Colorado & Southern Ry. track, north side of crossing; iron post stamped "5022 DENVER" - 5,020.084

Loveland via Colorado & Southern Ry. to Berthoud.

T. 5 N., R. 69 W., 2 miles south of Loveland, at road crossing, 20 feet east of center of tracks, on north side of public highway; iron post stamped "5050 DENVER" ---------- 5,048.335

	Feet.
Berthoud, 1.5 miles northeast of, sec. 11, T. 4 N., R. 69 W., 150 feet southeast of Munson's farmhouse, west side of highway, 0.5 mile east of railroad; iron post stamped "5082 DENVER"	5,080.085
Berthoud, sec. 14, T. 4 N., R. 69 W., northwest corner of Mount Avenue and Third Street, northeast corner of bank building; aluminum tablet stamped "5030 DENVER"	5,028.867
Berthoud, 2 miles south of, 0.5 mile northwest of Frankie's reservoir, at road crossing, 30 feet east of center of tracks, north side of highway; iron post stamped "5060 DENVER"	5,058.173

Bench marks established near Arkins.

Arkins, 0.8 mile south of, T. 6 N., R. 70 W., junction of roads at railroad crossing; iron post stamped "7249 DENV"	5,247.210
Arkins, 3.5 miles southwest of, 1 mile south of Big Thompson Canyon, 10 feet west of road, in rock; aluminum tablet stamped "5352 DENV"	5,350.723
T. 5 N., R. 70 W., SW. ¼ NW. ¼ sec. 9, Goodwins cabin, 2 feet south of road, 0.2 mile west of bridge 40, in flat rock; aluminum tablet stamped "5535 DENV"	5,534.050

Bench mark established near Masonville.

Masonville, 0.5 mile south of, sec. 15, T. 6 N., R. 70 W., 150 feet south of schoolhouse 51; bronze tablet stamped "5317 DENV"	5,315.207

Point near Pinewood east along road to Loveland.

Loveland, 9 miles west of, sec. 27, T. 5 N., R. 70 W., 1,000 feet east of base of Bald Mountain, beside telephone pole at side of road; iron post stamped "5440 DENV"	5,438.457
Loveland, 6 miles west of, sec. 23, T. 5 N., R. 70 W., junction of roads; iron post stamped "5242 DENV"	5,239.842
Loveland, 3 miles west of, sec. 20, T. 5 N., R. 69 W., between lakes, small summit in road; iron post stamped "5104 DENV"	5,102.293

Noland north along Chimney Hollow trail to Dry Creek.

Noland, 3 miles north of, sec. 16, T. 4 N., R. 70 W., 50 feet west of trail, near Goforth's homestead, in top of rock cliff; bronze tablet stamped "5596 DENV"	5,594.896
Noland, 6 miles north of, sec. 4, T. 4 N., R 70 W., on Reed's ranch, 500 feet southeast of house, in top of rock, west side of trail; bronze tablet stamped "5769 DENV"	5,767.156

Blackhawk, Boulder, Central City, and Georgetown quadrangles.

BOULDER, CLEAR CREEK, AND GILPIN COUNTIES.

The elevations in the following list are based on the elevation of the top of the lower pedestal at the southeast corner of the steps of the Colorado State capitol at Denver. The point is marked by the letters "U. S. B. M.," cut in the top of a granite block, and its elevation, obtained from the Coast and Geodetic Survey transcontinental line of levels, is accepted as 5,278.255 feet by the preliminary adjustment of 1911.

The leveling was done in 1902 and 1903 by F. M. Taylor and in 1904 by J. C. Fitterer.

BOULDER QUADRANGLE.

Boulder via stage road up Boulder Creek to Cochran's mill.

	Feet.
Boulder, 20 feet west of main entrance to courthouse; aluminum tablet stamped "5351 DENVER"	5,349.154
Oredel, east end of north abutment of bridge over Boulder Creek, in capstone; bronze tablet stamped "5732 DENVER"	5,729.922
Coburn mill, at forks of road, between mill and house, in rock ledge; aluminum tablet stamped "6036 DENVER"	6,034.498
Cochran's mill, 0.5 mile west of, south side of bridge over Boulder Creek, in top of shelf of road; aluminum tablet stamped "6541 Denver"	6,540.075

Boulder via Salina to Gold Hill.

Boulder Springs, sec. 2, T. 1 N., R. 71 W., north side of road, 50 feet south of confectionery factory, in face of rock; bronze tablet stamped "6261 DENV."	6,258.907
Salina, sec. 17, T. 1 N., R. 71 W., south side of railroad track opposite station, in rock cliff; aluminum tablet stamped "8571 DENV"	6,568.719
T. 1 N., R. 72 W., sec. 11, front face of Gold Hill schoolhouse, southeast corner of foundation; bronze tablet stamped "8297 DENV."	8,295.516

Chipmunk Gulch along road north to St. Vrain Creek, thence along creek road to Lyons.

Ward, 1 mile north of, 200 feet south of San Blas mill, in top of rock, east side of road; bronze tablet stamped "8901 DENV."	8,898.789
Ward, 4 miles north of, between new house and old log stable, 1,000 feet north of junction of roads to Allen Park and Gresham, in large bowlder; bronze tablet stamped "8573 DENV"	8,571.637
Ward, 8 miles north of, south side of road on summit 100 feet south of Miller Rock, in shelf of rock; bronze tablet stamped "8633 DENV"	8,630.75
Raymond's ranch, 2 miles east of, north side of road, 50 feet west of bridge across stream, in top of large bowlder; bronze tablet stamped "7449 DENV."	7,447.411
Lyons, 11 miles west of, north side of road, at junction of Middle and South St. Vrain creeks, at Sam Parish's place, in rock; bronze tablet stamped "6992 DENV"	6,990.113
Lyons, 9 miles west of, north side of road, 20 feet south of stable at Bummersville, in top of rock; bronze tablet stamped "6601 DENV."	6,599.346
Lyons, 6 miles west of, south side of road, 3 miles east of Bummersville, in top of large rock; bronze tablet stamped "5786 DENV."	5,784.425
Lyons, 2.5 miles west of, south side of road, 1,000 feet west of tollgate, in face of rock ledge; bronze tablet stamped "5493 DENV."	5,491.096
Lyons, sec. 18, T. 3 N., R. 70 W., in southeast corner of face of town hall; aluminum tablet stamped "5375 DENV."	5,373.281

Lyons northwest on Estes Park stage road.

	Feet.
Lyons, 3 miles northwest of. NE. ¼ sec. 11, T. 3 N., R. 71 W., north side of road, opposite slab ice house; iron post stamped "5580 DENV."	5,578.085

BLACKHAWK QUADRANGLE.

Bench marks established near Eureka.

Eureka, 1 mile west of, on small summit near pine tree, north side of road, in "Narrows," in top of rock; bronze tablet stamped "7347 DENVER"	7,345.943
Nederland, 3.5 miles east of, 30 feet west of bridge over creek, in "Castle Rock"; aluminum tablet stamped "7777 DENVER"	7,776.077

Nederland via Giggey's ranch and Gregory Canyon to Boulder.

Pine Glade schoolhouse, 100 feet west of, in top of rock; aluminum tablet stamped "8553 DENVER"	8,551.715
Pine Glade schoolhouse, 3 miles east of, 300 feet west of old stable, south side of road, in top of rock; aluminum tablet stamped "7801 DENVER"	7,800.395
Summit of ridge between Skates ranch and Gregory Canyon, north side of road, in top of rock; aluminum tablet stamped "7954 DENVER"	7,953.747
Summit, 1 mile west of stone house, north side of road, in top of rock; bronze tablet stamped "8002 DENVER"	8,000.332
Boulder, 1.2 miles southwest of, south side of road, 30 feet west of stream crossing, at mouth of Gregory Canyon, in top of bowlder; aluminum tablet stamped "5696 DENVER"	5,695.209

Blackhawk via Rollinsville to Nederland.

Blackhawk, Colorado & Southern Ry. station, south wall between window and door of office, in face of rock; aluminum tablet stamped "8041 DENVER"	8,041.045
Blackhawk, 3 miles north of, 100 feet south of junction of roads leading to Rollinsville, Golden, and Summit, in top of rock; aluminum tablet stamped "9269 DENVER"	9,268.578
Blackhawk, 6 miles north of, east side of road, 600 feet north of summit at turn in road to west, in top of bowlder; aluminum tablet stamped "9181 DENVER"	9,181.184
Rollinsville, 2.5 miles south of, 100 feet north of summit, 40 feet east of road, at turn west of Gilpin post office, in top of flat rock; aluminum tablet stamped "9019 DENVER"	9,020.234
Rollinsville, 50 feet back of post office, in top of large bowlder; aluminum tablet stamped "8443 DENVER"	8,443.252

Head of Lake Gulch to Justice mine.

Justice mine, 290 feet west of shaft house, in top of ledge, north side of road; aluminum tablet stamped "8721 DENVER"	8,720.482

Summit of Dory Hill divide, 3 miles north of Blackhawk, via Golden to Denver.[1]

	Feet.
Kriley's ranch house, 0.2 mile west of, 130 feet north of road, in stone ledge, 3 feet above ground; aluminum tablet stamped "8420 DENVER"	8,419.549
Junction Hill, summit of, 25 feet north of road, in top of stone ledge at surface of ground; aluminum tablet stamped "8740 DENVER"	8,739.746
Guy Hill, summit of divide, in top of granite bowlder, 10 feet north of road, 3 feet above ground; aluminum tablet stamped "7751 DENVER"	7,750.816
Tucker and Crawford gulches, forks of, 35 feet north of wagon road, 4 feet above ground, in top of granite ledge; aluminum tablet stamped "6907 DENVER"	6,906.787
Tucker and Half Mile gulches, 275 feet west of forks of, 10 feet south of road, in north side of large granite bowlder; aluminum tablet stamped "6219 DENVER"	6,218.716

Coal Creek west along highways to Gilpin.

Coal Creek, Denver, Northwestern & Pacific Ry. bridge across, in top of west concrete pier, south side of road, 6 feet above ground; aluminum tablet stamped "6599 DENVER"	6,598.343
Coal Creek, 3 miles from mouth of canyon, west side of road, 3 feet above ground, in top of large granite bowlder; aluminum tablet stamped "7330 DENVER"	7,329.203
Beaver Creek, 0.2 mile southwest of Bengson's ranch house, in top of large granite bowlder, east side of road; aluminum tablet stamped "7751 DENVER"	7,750.326
Beaver Hill, near summit of, 10 feet east of old road, in top of granite ledge; aluminum tablet stamped "8807 DENVER"	8,806.194
Belcher's ranch, 1 mile east of, 45 feet north of road, 1 foot above ground, in top of granite ledge; aluminum tablet stamped "9113 DENVER"	9,111.560
Rollinsville, intersection of Blackhawk, Golden, and Coal Creek roads, north side of road, 900 feet east of guidepost, in top of granite bowlder; aluminum tablet stamped "8998 DENVER"	8,996.900

CENTRAL CITY QUADRANGLE.

Nederland via Eldora, Baltimore, and Apex to Blackhawk.

Nederland, 50 feet east of post office, in top of rock; bronze tablet stamped "8237 DENVER"	8,235.996
Eldora, north side of road, in top of east end of large rock; aluminum tablet stamped "8643 DENVER"	8,641.380
Peterson Lake; surface of water, July 11, 1903	9,244
Baltimore, 2.5 miles north of, 50 feet west of junction of roads leading to Eldora, Rollins Pass, and Baltimore, in rock; bronze tablet stamped "9330 DENVER"	9,328.814
Baltimore, 50 feet east of post office, on line between lots 12 and 13, block 1, on large flat rock; aluminum tablet stamped "8913 DENVER"	8,912.548

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[1] The error distributed in this line is excessive.

	Feet.
Baltimore, 3 miles south of, 50 feet north of intersection of roads on summit of mountain, 0.5 mile north of Apex, in top of pointed rock; aluminum tablet stamped "10217 DENVER"	10,217.229
Apex, 200 feet east of schoolhouse, sec. 21, T. 2 S., R. 73 W., north end of town, at west side of road, in rock; aluminum tablet stamped "9857 DENVER"	9,856.750
Apex, 2 miles south of, 50 feet west of junction of roads, 40 feet north of Pine Creek, in top of rock; aluminum tablet stamped "9154 DENVER"	9,154.244
Blackhawk, 3 miles west of, at junction of roads leading to Gilpin, Missouri Lake, and Pine Creek, 200 feet east of Quartz Valley schoolhouse, beside telephone pole, in top of rock; aluminum tablet stamped "8514 DENVER"	8,514.143

Near Nederland.

Nederland, 2 miles south of, east side of road, 200 feet south of road crossing, near Beaver Creek, in top of rock; aluminum tablet stamped "8419 DENVER"	8,419.313

Kingston via Alice and Idaho Springs to Dover mines.

Kingston, south side of road, at junction of roads in village, in large flat rock; aluminum tablet stamped "10531 DENVER"	10,530.174
Yankee, 1 mile east of, 30 feet north of shaft house of North Star mine, in top of large rock; aluminum tablet stamped "10512 DENVER"	10,510.823
Alice, 50 feet northeast of post office, in top of flat rock; aluminum tablet stamped "10084 DENVER"	10,083.718
Alice, 3 miles east of, small summit 1,000 feet east of Seemann tunnel, north side of road, in top of rock; bronze tablet stamped "9167 DENVER"	9,166.169
Alice, 5.5 miles east of, junction of roads at mouth of Hamlin Gulch, north side of road beside mail box, in rock; bronze tablet stamped "8432 DENVER"	8,430.876
Idaho Springs, 3 miles west of, at bottom of dump, 100 feet north of power house, at Lucania tunnel, in top of flat rock; bronze tablet stamped "7818 DENVER"	7,816.414
Dover mines, 160 feet east of wagon bridge across Fall River, 35 feet north of road, in top of large bowlder; aluminum tablet stamped "7722 DENVER"	7,721.401

Point near Idaho Springs to Central City.

Idaho Springs, 3 miles north of, in top of Clear Creek-Gilpin Counties boundary monument No. 163, at summit of ridge at head of Virginia Canyon; aluminum tablet stamped "9363 DENVER"	9,361.786
Russel Gulch, in face of southeast corner of brick and stone post-office building; aluminum tablet stamped "9105 DENVER"	9,103.837
Nevadaville, in south face of corner stone under southeast corner of building; aluminum tablet stamped "9027 DENVER"	9,025.739
Central City, at east end of new brick schoolhouse, in large capstone at entrance; aluminum tablet stamped "8422 DENVER"	8,420.974

Idaho Springs to Empire.

	Feet.
Dumont, 1 mile east of, junction of road leading up North Spring Gulch, at Mackay mine shaft, in rock; aluminum tablet stamped "7827 DENVER"	7,825.519
Dumont, west end of, north side of road, 30 feet east of bridge over Mill Creek, in top of large rock; aluminum tablet stamped "7955 DENVER"	7,954.051
Lawson, 20 feet west of post office, in top of rock; aluminum tablet stamped "8143 DENVER"	8,142.019
Empire, 50 feet north of Colorado & Southern Ry. station, north side of road, in top of rock; aluminum tablet stamped "8250 DENVER"	8,248.517
Empire, 5 feet north of northeast corner of brick schoolhouse, in rock; aluminum tablet stamped "8603 DENVER"	8,601.454

Idaho Springs via Virginia Canyon to Sun and Moon mine, thence by Gibson Gulch to Colorado & Southern Ry. and return to Idaho Springs.

Idaho Springs, 1.1 miles north of, 125 feet south of junction of Idaho Springs, Central City, and Boomerang Gulch wagon roads, 3 feet above ground, at east side of road, in face of rock; aluminum tablet stamped "8084 DENVER"	8,083.238
Sun and Moon mine, 225 feet east of shaft house, in top of watch tower concrete pier; aluminum tablet stamped "9291 DENVER"	9,289.805
Summit mine, 50 feet southwest of shaft house, in top of granite stone at roadside; aluminum tablet stamped "8982 DENVER"	8,980.812

Point 3 miles north of Idaho Springs at summit of ridge at head of Virginia Canyon southwest to summit of Belleview Mountain (triangulation station).

Belleview Mountain, summit of, in top of bed rock; bronze triangulation tablet stamped "9684 DENVER"	9,683.528

Point 3 miles north of Idaho Spring southeast to Comstock mine.

Comstock mine, 70 feet northeast of shaft house entrance, in top of bed rock; aluminum tablet stamped "9156 DENVER"	9,155.552

Russell Gulch via Alps mine to Nevadaville.

Alps mine, small knob west, of, at summit, triangulation station; bronze tablet stamped "9594 DENVER"	9,593.272

Russell Gulch via Gettysburg and Baldwin mine to Saratoga mine and return to Russell Gulch via Gilpin tram.

Gettysburg mine, 150 feet southeast of, 20 feet east of road, in top of stone ledge; aluminum tablet stamped "9009 DENVER"	9,008.577
Baldwin mine, 65 feet northwest of power house, in top of granite ledge; aluminum tablet stamped "8730 DENVER"	8,729.234

Point near Saratoga mine to Kokomo mine.

Kokomo mine, 250 feet west of, ground at top of ledge; aluminum tablet stamped "8950 DENVER"	8,949,299

Blackhawk via road to Tucker mill.

	Feet.
Tucker's mill, 125 feet east of, 20 feet west of Hayseed Tunnel, in top of granite ledge 2 feet above ground; aluminum tablet stamped "8551 DENVER"	8,550.046

Blackhawk via road to Wheeler's mill.

Wheeler's mill, 225 feet west of, in face of granite ledge 2 feet above ground, north side of road; aluminum tablet stamped "8354 DENVER"	8,353.505

GEORGETOWN QUADRANGLE

Idaho Springs to Stanley Mills.

Idaho Springs, northwest corner of Sixteenth Avenue and Miner Street, in water table of First National Bank; aluminum tablet stamped "7541 DENVER"	7,540.077
Stanley Mills, 40 feet east of shaft house, in top of masonry road wall, 2 feet from end; aluminum tablet stamped "7667 DENVER"	7,666.496

Empire Pass via Georgetown to point 3 miles southwest of Idaho Springs.

Georgetown, 2 miles north of, summit of Empire Pass, on west side of road, at junction of roads, in rock; aluminum tablet stamped "8780 DENVER"	8,778.561
Georgetown, 10 feet south of east entrance of brick high school, in top of foundation stone; aluminum tablet stamped "8507 DENVER"	8,505.915
Georgetown, 2 miles east of, summit of Griffith Mountain, 300 feet north of Comet mine, between electric light lines, in top of rock; bronze tablet stamped "11000 DENVER"	10,999.015
Georgetown, 5 miles east of, north side of Cascade Creek, by trail, at old sawmill, in top of large flat rock; bronze tablet stamped "9593 DENVER"	9,591.914
Idaho Springs, 6 miles east of, junction of roads up Chicago and Cascade Creeks, 20 feet north of bridge over Cascade Creek, in top of rock; aluminum tablet stamped "8532 DENVER"	8,530.747
Idaho Springs, 3 miles southwest of, 2,000 feet north of Peters tunnel, west side of road, in rock; aluminum tablet stamped "7919 DENVER"	7,917.608

Georgetown via public road and trail to point 0.8 mile south of Cedar Lake.

Clear Lake; surface of water, September 24, 1903	9,869
Georgetown, 3.5 miles south of, at south end of swamp, 30 feet west of road, 0.7 mile south of Clear Lake, in top of large rock; aluminum tablet stamped "9991 DENVER"	9,989.955

Junction of Cascade and Chicago creeks via trail up South Chicago Creek to bench mark 4 miles south of junction.

Cascade and Chicago creeks, 4 miles south of junction of, west side of trail, in top of shelf of large granite bowlder; aluminum tablet stamped "9662 DENVER"	9,661.194

Georgetown along Colorado & Southern Ry. via Silver Plume to Terrible mine.

Georgetown, 10 feet south of east entrance to brick high school, in top of foundation stone; aluminum tablet stamped "8507 DENVER"	8,505.941

	Feet.
Silver Plume, 75 feet northeast of railroad station, 4.5 feet north of southeast corner of brick building, in foundation stone of west wall, 2 feet above ground; aluminum tablet stamped "9114 DENVER"	9,113.328
Terrible mine, 25 feet west of tunnel entrance, 2 feet above ground, in face of granite wall; aluminum tablet stamped "9271 DENVER"	9,270.144

Silver Plume along wagon roads to 730 mine.

Pelican Tunnel, 120 feet southwest of, in face of granite rock; aluminum tablet stamped "9592 DENVER"	9,591.15
730 mine, 120 feet southeast of tunnel mouth, in face of granite rock, 5 feet above ground; aluminum tablet stamped "10451 DENVER"	10,450.398

Fort Collins, Livermore, Long Peak, and Mount Olympus quadrangles.

LARIMER COUNTY.

The elevations in the following list are based on the elevation of the lower pedestal at the southeast corner of the steps of the Colorado State capitol, at Denver. The elevation is obtained from the Coast and Geodetic Survey transcontinental line of levels and is accepted as 5,278.255 by the approximate adjustment of 1911.

The leveling was done in 1905 by G. A. Joslin.

The line from Belleview to Livermore was run as a precise line. The circuit from Forks Hotel via Alvord and return to Forks Hotel was a single line using the same level. The balance of level lines were run with a Y level and New York rods.

FORT COLLINS QUADRANGLE.

Fort Collins southeast 3 miles along road, thence east to sec. 9, T. 7 N., R. 68 W., thence to crossroads 2 miles north of Wellington, thence west to corner of secs. 23, 24, 25, and 26, T. 9 N., R. 69 W.

Fort Collins, in west end of stone doorsill, main entrance to First National Bank; bronze tablet stamped "4981 DENVER"	4,979.134
Fort Collins, 3 miles east of, sec. 17, T. 7 N., R. 68 W., east side of road, junction with road turning north, 500 feet southeast of Slackett's ranch; iron post stamped "4927 DENVER"	4,925.699
T. 7 N., R. 68 W., 0.2 mile north of corner of sec. 9, 1 mile north of Pitcher's house, 30 feet west of road; iron post stamped "4937 DENVER"	4,935.489
T. 8 N., R. 68 W., southeast corner of sec. 28, 4 miles north of Pitcher's house, near telephone pole; iron post stamped "5021 DENVER"	5,019.120
T. 8 N., R. 68 W., northeast corner of sec. 16, 3 miles south of Wellington, in front of Carter's house; iron post stamped "5127 DENVER"	5,125.699
Wellington, west side of First National Bank Building in second stone step; bronze tablet stamped "5202 DENVER"	5,200.749
T. 9 N., R. 68 W., northeast corner of sec. 29, 1.8 miles east of Poudre Valley Irrigation Co. reservoir No. 2, at foot of telephone pole; iron post stamped "5254 DENVER."	5,252.255

	Feet.
T. 9 N., R. 69 W., 600 feet east of corner of secs. 23, 24, 25, and 26, 9.5 miles north of Fort Collins, 150 feet southeast of Annie D. Winter's farmhouse, 16 feet west of gate; iron post stamped "5290 DENVER"	5,288.167

Fort Collins along road to La Porte, thence by Union Pacific R. R. via Bellevue to old Stout post office.

T. 7 N., R. 69 W., corner of secs. 4, 5, 8, and 9, corner of Wm. S. Smith's property, at foot of telegraph pole; iron post stamped "5116 DENVER"	5,114.407
La Porte, opposite post office, at foot of telegraph pole; iron post stamped "5063 DENVER"	5,061.549
Bellevue, top step, north side Bellevue Mercantile Co. building; aluminum tablet stamped "5125 DENVER"	5,123.988
Bellevue, 3.7 miles south of, sec. 7, T. 7 N., R. 69 W., 200 feet from bridge 260, north end of gate to Lamb's ranch; iron post stamped "5303 DENVER"	5,301.693
T. 7 N., R. 69 W., between secs. 29 and 30, 1.5 miles north of Stout, 0.3 mile south of Johnson spur, at switch, east side of road, foot of fence post; iron post stamped "5322 DENVER"	5,320.670
Stout, abandoned post office, sec. 7, T. 6 N., R. 69 W.; chisel mark on west end of doorsill	5,275.371

Point near Masonville.

Masonville, 2.5 miles northwest of, sec. 9, T. 6 N., R. 70 W., 4 feet north of L. A. Sheldons ranch gate; iron post stamped "5478 DENVER"	5,476.646

Point near Bellevue to sec. 18, T. 9 N., R. 70 W.

Bellevue, 3.2 miles northwest of, opposite gate of G. Shipp's ranch, north side of road; iron post stamped "5227 DENVER"	5,225.318
Engleside, 2.3 miles south of, sec. 1, T. 8 N., R. 70 W., west of road, 2 feet south of telephone pole; iron post stamped "5378 DENVER"	5,376.761
Engleside, 1.2 miles north of, sec. 18, T. 9 N., R. 70 W., 0.2 mile south turn in telegraph line west, west side of road, foot of telegraph pole; iron post stamped "5587 DENVER"	5,585.521

Bench marks near Fort Collins.

Fort Collins, 3.5 miles south of, corner of secs. 25, 26, 35, and 36, T. 7 N., R. 69 W., southwest corner of sec. 25, at fence corner; iron post stamped "5027 DENVER"	5,025.147
Fort Collins, State agricultural building, at east entrance to main building, in north end of first stone step; aluminum tablet stamped "4998 DENVER"	4,996.478
Fort Collins, 4 miles north of, 800 feet west of A. F. Stauff's farmhouse, west of road, at southwest fence corner at mouth of lane running west; iron post stamped "5111 DENVER"	5,109.118
Fort Collins, 6.5 miles north of, top of ridge, 6 feet east of road and 20 feet west of railroad grade; iron post stamped "5268 DENVER"	5,266.071

Masonville via Stout post office to Fort Collins.

	Feet.
Masonville, 2.5 miles northeast of, sec. 1, T. 6. N., R. 70 W., summit of divide between Redstone and Spring Canyon; iron post stamped "5766 DENV."	5,763.548
Fort Collins, 5.5 miles southwest of, between secs. 33 and 34, T. 7 N., R. 69 W., 1 mile east of Stout post office, at intersection of roads; iron post stamped "5150 DENV."	5,147.991

LIVERMORE QUADRANGLE.

Bench marks established near public-land corners.

T. 6 N., R. 70 W., sec. 5, summit of Fletcher Hill, 5 feet west of road, 5 feet east of fence, in low rock; aluminum tablet stamped "6047 DENVER"	6,046.203
T. 7 N., R. 71 W., probably sec. 14, summit of Little Dead Man Hill, 40 feet north of road, in low rock, near stone monument; aluminum tablet stamped "6492 DENVER"	6,490.752
T. 7 N., R. 71 W., sec. 15 or 16, 2.5 miles northwest of Little Dead Man Hill, 1.4 miles northwest of forks of road, 30 feet northwest of creek, south side of road, large rock, beside stone monument; aluminum tablet stamped "6516 DENVER"	6,514.067
T. 7 N., R. 71 W., sec. 17, 5.5 miles northwest of Little Dead Man Hill, 0.9 mile north of deserted cabin, south edge of road, in low rock; aluminum tablet stamped "6943 DENVER"	6,941.398
T. 7 N., R. 72 W., 800 feet south of Miller's ranch house, crossing old hill road with new creek road, between creek and road, in rock; aluminum tablet stamped "7288 DENVER"	7,286.537
T. 7 N., R. 71 W., southwest corner of sec. 4, 1.5 miles southwest of Stove Prairie schoolhouse, in gully near dugout, 20 feet east of pine tree, south side of road, in rock; aluminum tablet stamped "7272 DENVER"	7,270.464
T. 8 N., R. 71 W., sec. 29, 1.5 miles northeast of Stove Prairie schoolhouse, 100 feet northwest of road crossing of creek, foot of little hill, east edge of grove of quaking aspens, 20 feet west of road, 10 feet southeast of pine tree; aluminum tablet stamped "7086 DENVER"	7,084.732
Stove Prairie Landing, 0.8 mile south of, sec. 4, T. 8 N., R. 71 W., cabin on creek bank, west edge of road, east bank of creek, in large flat rock; aluminum tablet stamped "6314 DENVER"	6,312.285
Stove Prairie Landing, 1.2 miles west of, sec. 1, T. 8 N., R. 72 W., 150 feet west of rock monument at end of railroad grade, 60 feet south of pine tree opposite mouth of dry gulch, 100 feet from river, in bowlder, 25 feet high; aluminum tablet stamped "6115 DENVER"	6,113.420
Stove Prairie Landing, 2.7 miles north of, sec. 30, T. 9 N., R. 71 W., 100 feet from summit of pass, 50 feet east of road, by pile of rocks, low flat rock; aluminum tablet stamped "6927 DENVER"	6,926.112
Log Cabin, 5 miles east of, sec. 24, T. 9 N., R. 72 W., 200 feet west of town line, 40 feet north of road, near fence corner, in granite rock; aluminum tablet stamped "7050 DENVER"	7,048.852
Livermore, 6.9 miles east of, sec. 9, T. 9 N., R. 71 W., west edge of road, in rock in road opposite telegraph pole; aluminum tablet stamped "6533 DENVER"	6,531.723

	Feet.
Livermore, 3.4 miles east of, sec. 35, T. 10 N., R. 71 W., above road on south side, in rock; aluminum tablet stamped "5994 DENVER"	5,993.278
Livermore, west edge of hotel steps, in cement walk; aluminum tablet stamped "5733 DENVER"	5,731.814
Forks Hotel, 2.5 miles southwest of, sec. 2, T. 9 N., R. 70 W., 0.2 mile north of F. W. Rigdon's post box, in small rock by pile of stone; aluminm tablet stamped "5927 DENVER"	5,925.748
Forks Hotel, sec. 23, T. 10 N., R. 70 W., between forks of road, 200 feet east of windmill, in sandstone rock; aluminm tablet stamped "5887 DENVER"	5,885.792

Forks Hotel via road to Alford, thence east to State road and south to Livermore.

Forks Hotel, 3 miles northwest of, sec. 20, T. 10 N., R. 70 W., turn in road to St. Cloud at foot of signboard "St. Cloud to Latimar River"; iron post stamped "5999 DENVER"	5,097.633
Alford, 2.2 miles south of, sec. 13, T. 10 N., R. 71 W., 800 feet above mouth of canyon, west side of road, east edge of creek, in low granite rock; aluminum tablet stamped "6141 DENVER"	6,140.081
Alford, hill back of town, sec. 9, T. 10 N., R. 71 W., south edge of road, in surface rock 20 feet square; aluminum tablet stamped "6353 DENVER"	6,351.850
Alford, 3 miles west of, sec. 5, T. 10 N., R. 71 W., 0.2 mile north of Virginia Dale road with St. Cloud road, south edge of hill, west edge of road, in large rock; aluminum tablet stamped "6635 DENVER"	6,633.565
T. 11 N., R. 70 W., sec. 36, 7.8 miles north of Forks Hotel, 600 feet south of telegraph line crossing road, east side of road, in rock; aluminum tablet stamped "6516 DENVER"	6,514.276
T. 10 N., R. 70 W., sec. 8, 4.9 miles south of Forks Hotel, top of hill, south side of road, in granite rock; aluminum tablet stamped "6287 DENVER"	6,285.123

Bench marks established at public-land corners.

T. 10 N., 72 W., sec. 12, 100 feet west of line fence, 150 feet northwest of gate to Bullards ranch, 50 feet east of corner to fence, in round rock 4 feet high and 7 feet in diameter; aluminum tablet stamped "6701 DENV"	6,699.176
T. 11 N., R. 72 W., in east part of sec. 36, summit of hill, 15 feet south of fence, in rock cairn 2 feet high; aluminum tablet stamped "6825 DENV"	6,823.877

Waverly north along road to Brennigan Spring.

McGimleys farmhouse, 0.8 mile northeast of, 60 feet west of railroad grade, at wire fence east and west; iron post stamped "5416 DENVER"	5,414.182
Boxelder Creek crossing, 1,900 feet south of, at fence corner, 45 feet east of public road, on old railroad grade; iron post stamped "5528"	5,526.325
Warren sheep camp, 2 miles south of, 100 feet west of railroad grade, 60 feet southwest of road forks, at fence corner; iron post stamped "5631 DENVER"	5,629.066

	Feet.
Warren sheep camp, 1 mile north of, at point of curve east, 30 feet west of old railroad grade, 15 feet east of wagon road; iron post stamped "5805 DENVER"	5,803.232
Jack Spring ranch, 1,000 feet south of, 6 feet west of gate, 900 feet east of corner of secs. 5, 6, 7, and 8, T. 11 N., R. 68 W.; iron post stamped "6045 DENVER"	6,043.210
Brennigan Spring, 1,000 feet north of, on ridge by wire-fence line between Rs. 68 and 69 W.; iron post stamped "6569 DENVER"	6,567.063

LONGS PEAK QUADRANGLE.

Boston mine to Ward.

Ward, 1 mile south of, sec. 7, T. 1 N., R. 72 W., 500 feet north of Boston mine, in face of rock east side of road; bronze tablet stamped "8594 DENV."	8,591.744
Ward, sec. 1, T. 1 N., R. 78 W., in southeast corner of wall of railroad station; aluminum tablet stamped "9254 DENV."	9,252.613

Vicinity of Estes Park (single spur line).

Estes Park, sec. 25, T. 5 N., R. 72 W., 300 feet northwest of post office, north side of road, in top of rock; aluminum tablet stamped "7549 DENV."	7,546.877
Estes Park, 2 miles northwest of, sec. 35, T. 5 N., R. 72 W., 700 feet north of south bank of Thompson River, in rock beside pine tree; bronze tablet stamped "7626 DENV."	7,623.697

MOUNT OLYMPUS QUADRANGLE.

Lyons via stage road to point near Dunraven ranch, Estes Park.

Lyons, 5.5 miles northwest of, top of Jordan Hill, north side of road; iron post stamped "6650 DENV."	6,648.169
Lyons, 8 miles northwest of, 75 feet north of bridge across Little Thompson River, at junction of Allen Park and Estes Park roads; iron post stamped "6704 DENV."	6,702.217
Lyons, 11 miles northwest of, 8 feet north of road, at foot of pine tree; iron post stamped "7329 DENV."	7,326.955
Lyons, 14 miles northwest of, 0.25 mile northwest of Meadowdale stock ranch, pine tree north side of road; iron post stamped "7824 DENV."	7,822.902
Estes Park, 5 miles east of, sec. 28, T. 5 N., R. 72 W., at junction of Estes Park and Loveland roads; iron post stamped "7594 DENV."	7,591.835

Point near Estes Park east by road to Pinewood.

Estes Park, 6 miles east of, sec. 25, T. 5 N., R. 72 W., 300 feet west of summit, rock south side of road, set in top of; bronze tablet stamped "8584 DENV."	8,582.442
Estes Park, 9 miles east of, sec. 23, T. 5 N., R. 71 W., 500 feet west of W. L. Walker's ranch, in top of rock, south side of road; bronze tablet stamped "7599 DENV."	7,597.285
Pinewood, 0.5 mile west of, sec. 26, T. 5 N., R. 71 W., 200 feet west of house, in face of rock, south side of road; bronze tablet stamped "6673 DENV."	6,671.370

	Feet.
Pinewood, 0.5 mile northeast of, in sec. 11, T. 5 N., R. 70 W., north side of road at summit of Bald Mountain; iron post stamped "6772 DENV."	6,771.490

Lyons to Noland.

T. 3 N., R. 70 W., sec. 5, southwest corner of Noland schoolhouse; aluminum tablet stamped "6025 DENV."	6,023.275

Sec. 1, T. 5 N., R. 71 W., along stage road to point 5 miles east of Estes Park.

T. 5 N., R. 71 W., sec. 6, 900 feet west of bridge 5, 50 feet south of creek, 2 feet north of road, in small rock; aluminum tablet stamped "5808 DENVER"	5,806.828
T. 6 N., R. 71 W., sec. 33, 0.5 mile northwest of forks of Big Thompson Creek, in front of Hersman place; iron post stamped "6343 DENVER"	6,341.579
T. 5 N., R. 71 W., sec. 3, 0.3 mile west of forks of Big Thompson Creek, on south fork, 100 feet west of turn of creek, 100 feet east of cabin, 10 feet south of road, in large rock; aluminum tablet stamped "6201 DENVER"	6,199.700
T. 5 N., R. 71 W., sec. 8, 0.4 mile west of bridge 9, 3 feet south of road, flat rock; aluminum tablet stamped "6778 DENVER"	6,776.359
T. 5 N., R. 72 W., sec. 13, 200 feet south of creek, 0.9 mile west of bridge 11, west end of little flat, 5 feet south of road; iron post stamped "7003 DENVER"	7,001.974
T. 5 N., R. 72 W., sec. 22, 500 feet east of bridge 13, south edge of road, in large rock; aluminum tablet stamped "7269 DENVER"	7,267.411
Estes Park, 0.5 mile east of, junction of Estes Park and Loveland roads; iron post stamped "7594 DENVER"	7,591.900

Eaton quadrangle.

LARIMER AND WELD COUNTIES.

The elevations in the following list are based upon the precise level line of the Coast and Geodetic Survey traversing this area.

The leveling was done in 1905 by C. I. Anderson, in 1906 by G. A. Joslin, and in 1908 by W. R. Winstead.

EATON QUADRANGLE.

Fort Collins east along wagon road to Eaton.

	Feet.
Fort Collins, 3 miles southeast of, sec. 17, T. 7 N., R. 68 W., 500 feet southeast of Slockett's ranch, at junction of road north, on east side of road; iron post stamped "4927 DENVER"	4,925.723
Timnath, 2.5 miles north of, northeast corner of sec. 22, T. 7 N., R. 68 W., at crossroads, on southwest corner of intersection, 25 feet south of corner, opposite H. M. Lewis's farmhouse; iron post stamped "4916 DENVER"	4,914.589
Timnath, southeast corner of Timnath schoolhouse, in corner stone, third course from ground; aluminum tablet stamped "4877"	4,875.941
T. 7 N., R. 68 W., southeast corner of, 2.5 miles southeast of Timnath, north side of road, 4 feet west of fence corner; iron post stamped "4881 DENVER"	4,879.594

	Feet.
Windsor, 3 miles north of, 800 feet south of northeast corner of sec. 4, T. 6 N., R. 67 W., on west corner of road intersection at Geo. Bremlnan's ranch house, 500 feet south of Windsor reservoir; iron post stamped "4924 DENVER"	4, 922. 646
Severance, 1 mile east of, southwest corner of sec. 36, T. 7 N., R. 67 W., 6 miles west of Eaton, northwest corner of road intersection, at Walter Baldridge ranch; iron post stamped "4894 DENVER"	4, 892. 649
Eaton, 3 miles west of, 2 feet east of southwest corner of sec. 34, T. 7 N., R. 66 W., north side of wagon road; iron post stamped "4862 DENVER"	4, 860. 516
Eaton, southwest corner of sec. 31, T. 7 N., R. 66 W., southwest corner of schoolhouse lot; iron post stamped "4826 DENVER"	4, 824. 681

Eaton east 7 miles, north 6 miles, west 1 mile, north 2 miles, and west to Pierce.

Eaton, 3 miles east of, southwest corner of sec. 34, T. 7 N., R. 65 W., northeast corner of crossroads, 150 feet east of bridge over Lone Tree Creek, at John Ward's ranch house; iron post stamped "4774 DENVER 1906"	4. 772. 753
Canal, 0.2 mile south of, sec. 18, T. 7 N., R. 64 W., east side of road beside fence; iron post stamped "4851 DENV 1906"	4, 849. 517
T. 8 N., R. 64 W., sec. 32, summit of little ridge; iron post stamped "5007 DENV 1906"	5, 004. 722
T. 8 N., R. 64 W., southwest corner of sec. 19, 6 feet east of corner stake; iron post stamped "5021 DENV 1906"	5, 018. 812
Pierce, 5 miles east of, at foot of fence corner opposite Olive Branch school district 62; iron post stamped "4950 DENV 1906"	4. 957. 848
Pierce, 1.8 miles east of, road corner, 5 feet from fence corner post on south side of road; iron post stamped "5054 DENV 1906"	5. 051. 595

Pierce west along first wagon road north of Pierce to Blackhollow, thence southwest to Fort Collins road to sec. 28, T. 8 N., R. 68 W.

Pierce, 3 miles west of, north side of road, 4 feet east of north and south fence, foot of third post north of fence corner; iron post stamped "5160 DENV 1906"	5, 158. 563
Pierce, 5.8 miles west of, 0.6 mile west of Walker's ranch house, summit of hill, north side of road; iron post stamped "5280 DENV 1906"	5. 278. 463
Blackhollow, 0.8 mile southwest of, summit of hill west of first draw west of Blackhollow, 15 feet north of road; iron post stamped "5171 DENV 1906"	5, 169. 258
T. 8 N., R. 67 W., northwest corner of section 31, on line between Larimer and Weld Counties; iron post stamped "5159 DENV 1906"	5,157. 321

Dover north along Union Pacific R. R. to Carr.

Dover, in front of section house; top of rail	5,409
Dover, 3 miles northwest of, 0.25 mile northwest of section post, 0.5 mile southeast of "Decker 1 mile" post, east side of track, by telegraph pole; iron post stamped "5524 DENV 1906"	5, 522. 480

	Feet.
Carr, 2.9 miles southeast of, 1,000 feet north of cut, east side of track, 6 feet west of road, beside telegraph pole; iron post stamped "5632 DENV 1906"	5,630.487
Carr, in front of station; top of east rail	5,704.0

Carr southeast along road via Slayton's ranch to sec. 28, T. 10 N., R. 65 W., thence south to sec. 6, T. 9 N., R. 65 W., thence west to Dover.

Carr, 2.9 miles southeast of, summit of first ridge east of Lone Tree Creek, 10 feet north of road; iron post stamped "5650 DENV 1906"	5,648.497
Carr, 6.4 miles southeast of, 1.8 miles northwest of Slayton's ranch house, summit of ridge between Little Owl Creek and Owl Creek, 10 feet north of road; iron post stamped "5639 DENV 1906"	5,637.528
T. 10 N., R. 66 W., northwest corner of sec. 12, 1 mile southeast of Slayton's ranch house, at forks of southeast and east roads, on line with east and west fence on west side of Owl Creek; iron post stamped "5460 DENV 1906"	5,458.452
Slayton's ditch camp, 1.1 miles southeast of west side of Eastman Creek, 100 feet north of sheep corral, 50 feet from road; iron post stamped "DENV 5336 1906"	5,334.502
T. 10 N., R. 65 W., southeast corner of NW. ¼ sec. 28, Eastman Creek, Fred Abbott's ranch, at foot of fence post, 10 feet west of road; iron post stamped "5258 DENV 1906"	5,256.559
T. 9 N., R. 65 W., northeast corner of sec. 6, 30 feet southwest of crossing of plowed furrows; iron post stamped "5345 DENV 1906"	5,343.338
Dover, 3.3 miles east of, north line of sec. 2, T. 9 N., R. 66 W., near northwest corner, 300 feet east of creek, 0.3 mile north of sheep corral; iron post stamped "5290 DENV 1906"	5,288.566

Point 3 miles east of Olive Branch schoolhouse along highways north and west to Dover.

T. 8 N., R. 64 W., southwest corner of sec. 19, 3 miles east of Olive Branch schoolhouse, 6 feet east of corner stake; iron post stamped "5021 DENV 1906	5,018.812
T. 8 N., R. 64 W., southwest corner of sec. 7, 3 feet east of fence corner, Harry Stapp's ranch; iron post stamped "5092 DENVER 1908"	5,090.638
T. 9 N., R. 64 W., southwest corner of sec. 19, 3 feet east of fence corner, 150 feet southeast of house; iron post stamped "5210 DENVER 1908"	5,208.397
T. 9 N., R. 65 W., southeast corner of sec. 15, 3 feet south of fence corner, 500 feet southwest of house; iron post stamped "5208 DENVER 1908"	5,206.385
T. 9 N., R. 65 W., northeast corner of sec. 17, 30 feet southeast of fence corner, 3 feet east of corner stone; iron post stamped "5175 DENVER 1908"	5,172.840
T. 9 N., R. 66 W., northeast corner of sec. 14, 2,640 feet south of house, north of fence corner 3 feet; iron post stamped "5230 DENVER 1908"	5,228.808
Dover, 3 miles southeast of, northeast corner of sec. 9, T. 9 N., R. 66 W., 1,200 feet north of house, 3 feet southeast of fence corner; iron post stamped "5306 DENVER 1908"	5,304.047

	Feet.
Dover, in southeast corner of section yard, on top of rock; square marked "U. S. □ B. M." (Coast and Geodetic Survey bench mark)	5, 407. 237

Point 0.85 mile southeast of Dover south along Union Pacific R. R. to Nunn, thence west, north, and east to point of beginning.

Dover, 2.3 miles southeast of, at milepost 75, 60 feet west of track, near wire fence; iron post stamped "5320 DENVER 1908"	5, 318. 680
Nunn, 500 feet southwest of station, northeast corner of amusement hall at Kent Hotel, 500 feet east of center of sec. 33, T. 9 N., R. 66 W.; iron post stamped "5186 DENVER 1908"	5, 184. 899
Nunn, 3 miles northwest of, northeast corner of sec. 36, T. 9 N., R. 67 W., 30 feet southwest of corner stone; iron post stamped "5235 DENVER 1908"	5, 232. 982
Nunn, 6 miles northwest of, northeast corner of sec. 12, T. 9 N., R. 67 W., 4 feet east of fence; iron post stamped "5337 DENVER 1908"	5, 335. 235

Nunn south along Union Pacific R. R. to Eaton.

Nunn, 2.6 miles southeast of, about center of secs. 10 and 15, T. 9 N., R. 66 W., 500 feet west of house, 60 feet west of track, north of road, at road crossing; iron post stamped "5112 DENVER 1908"	5, 110. 353
Pierce, 1,000 feet west of station, 5.3 miles southeast of Nunn, in southwest corner of west face of Shafer & Stovall's brick store; aluminum tablet stamped "5041 DENV 1908"	5, 039. 488
Pierce, 2 miles southeast of, 600 feet east of quarter corner on south side of sec. 35, T. 8 N., R. 66 W., on the south township line of T. 8 N., 60 feet west of track, north of road at road crossing; iron post stamped "4990 DENVER 1908"	4, 988. 217
Ault, 300 feet southwest of station, in southeast corner of east face of W. N. Williamson's real estate and insurance office; aluminum tablet stamped "4840 DENVER 1908"	4, 939. 863
Ault, 2 miles southeast of, 60 feet west of track, north of road, 1,200 feet east of quarter corner on south side of sec. 24, T. 7 N., R. 66 W., at road crossing 60-D-60-E; iron post stamped "4867 DENVER 1908"	4, 865. 250

Carr north along Union Pacific R. R. to Athol, Wyo.

Carr, in southeast corner of the yard of railroad section house, on top of granite post; square (Coast and Geodetic Survey bench mark)	5, 702. 976
Carr, 3 miles north of, 600 feet north of milepost 89, 63 feet east of track, 3 feet east of wire fence, 10 feet west of road, 21 feet south of house; iron post stamped "5840 DENVER 1908"	5, 838. 236
Carr, 6 miles north of, 300 feet north of milepost 92, 600 feet south of electric signal, 63 feet east of track, 3 feet east of wire fence, 2,000 feet northwest of tent, 150 feet west of road; iron post stamped "5993 DENVER 1908"	5, 991. 481

Northwest corner of sec. 12, T. 10 N., R. 66 W., east 2 miles, north 1.5 miles, east 7.5 miles, south 4.5 miles, thence west to sec. 28, T. 10 N., R. 65 W.

	Feet.
T. 10 N., R. 66 W., northwest corner of sec. 12, 1 mile southeast of Slayton's ranch house at forks of southeast and east roads, on line with east and west fence, west side of Owl Creek; iron post stamped "5460 DENV 1908"	5,458.352
T. 11 N., R. 65 W., SW. ¼ sec. 32, 0.2 mile northeast of section corner at crossroad, in northwest corner of roads; iron post stamped "5433 DENVER 1908"	5,431.398
T. 11 N., R. 65 W., center of sec. 34, 3 feet north of fence corner; iron post stamped "5544 DENVER 1908"	5,542.866
T. 11 N., R. 64 W., on township line, quarter corner of sec. 36, 30 feet northeast of corner stone; iron post stamped "5394 DENVER 1908"	5,392.254
T. 10 N., R. 64 W., about center of sec. 33, 1 mile east and 1.3 miles north of Willow Creek, on top of large hill; iron post stamped "5413 DENVER 1908"	5,411.872
T. 10 N., R. 64 W., about center of sec. 16, 1.7 miles south of Willow Creek, 1 mile north of big hill, 500 feet west of old road, on top of small hill; iron post stamped "5403 DENVER 1908"	5,401.754
T. 10 N., R. 65 W., near northwest corner of sec. 24, 1,000 feet southeast of section stone, 0.8 mile north of house; iron post stamped "5427 DENVER 1908"	5,425.778

Carr northwest along highways to point 1 mile north of Warren's siding.

Carr, 5 miles northwest of, at road to North Cheyenne and Fort Collins telephone line, 30 feet east of road; iron post stamped "5907 DENVER 1908"	5,904.905
Carr, 6.5 miles northwest of, at second-class road fork east, 1,200 feet west of house, 80 feet west of road; point on rock marked "5958"	5,955.98

Holyoke quadrangle.

SEDGWICK COUNTY.

The approximate elevations in the following list depend on the bench mark established in the season of 1896 at Sidney, Nebr., consisting of a copper bolt set in the astronomic monument in the parade grounds of old Fort Sidney, marked "U.S.G.S. 4086 feet B.M." The elevation of this bench mark has been accepted as 4,086.279 feet above mean sea level, based on Union Pacific Railroad datum.

The leveling was done by R. C. Cornish in 1897.

HOLYOKE QUADRANGLE.

Bench marks near Julesburg.

	Feet.
T. 12 N., R. 45 W., at section corner on Nebraska-Colorado State line, 0.5 mile west of Lodgepole Creek; iron post stamped "SIDNEY 3591"	3,590.886
Julesburg, T. 12 N., R. 45 W., in astronomical monument; bronze tablet stamped "SIDNEY 3560"	3,560.480
Julesburg, T. 12 N.. R. 44 W., at railroad station; iron post stamped "SIDNEY 3469"	3,469.064

Castle Rock and Colorado Springs quadrangles, and Pikes Peak special quadrangle.

EL PASO, PUEBLO, AND TELLER COUNTIES.

The elevations in the following list are based on the transcontinental line of precise levels of the Coast and Geodetic Survey along the Atchison, Topeka & Santa Fe and the Chicago, Rock Island & Pacific railways in this section.

The leveling in the Colorado Springs quadrangle was done in 1903 by J. E. Chapson, in 1905 by C. I. Anderson, and in 1906 by G. A. Joslin; that in the Pikes Peak special quadrangle in 1903 by J. E. Chapson and in 1907 by Charles Hartman; and that in the Castle Rock quadrangle in 1905 by C. I. Anderson.

COLORADO SPRINGS QUADRANGLE.

Colorado Springs via Denver & Rio Grande R. R. to Adams Crossing, thence along roads to Garden of the Gods and return to Colorado Springs.

	Feet.
Colorado Springs, 2,000 feet north of station, west of track, north abutment of railroad bridge over Monument Creek; bottom of square hole in second rock from end where offsets begin (bench mark A, Coast and Geodetic Survey)	5, 987. 455
Colorado Springs, 2,000 feet north of station, in west end of north abutment of plat girder bridge over Monument Creek, on first stone where offsets begin, 4 feet west of Coast Survey bench mark; aluminum tablet stamped "5988 ADJ 1903"	5, 987. 473
Cathedral Rock, in south face, 2 feet above ground; aluminum tablet stamped "6432 ADJ 1903"	6, 431. 532
Cathedral Rock, east side of, in rock at gate to Garden of the Gods, 5 feet above ground; aluminum tablet stamped "6415 ADJ 1903"	6, 414. 065
Colorado Springs, 2 miles west of, top of hill opposite Brewer house, 30 feet south of road; iron post stamped "6310 ADJ 1903"	6, 309. 023

Colorado Springs via Denver & Rio Grande R. R. to Fountain, thence via Colorado & Southern Ry to Manitou Junction, thence along roads and Chicago, Rock Island & Pacific Ry. to Elsmere.

Colorado Springs, 1.5 miles southeast of, twelfth stone from top of upper face of southeast wing wall of masonry culvert; aluminum tablet stamped "5874 ADJ 1903"	5, 872. 917
Colorado Springs, 5 miles southeast of, at Skinner ranch, 300 feet east of gate, outside fence corner, in sec. 3, T. 15 S., R. 66 W.; iron post stamped "5777 ADJ 1903"	5, 776. 298
Crews, 300 feet north of station, T. 15 S., R. 65 W., 2 feet west of fence corner; iron post stamped "5651 ADJ 1903"	5, 649. 943
Fountain, on southeast corner of store building of F. E. Torbit, 5 feet above walk, in lava rock; aluminum tablet stamped "5547 ADJ 1903"	5, 545. 979
Fountain, 2.7 miles northeast of, fence corner east of right of way, at summit; iron post stamped "5612 ADJ 1903"	5, 611. 060
Franceville Junction, 1 mile south of, southwest corner of sec. 15, T. 15 S., R. 65 W., 11 feet east of track, at fence; iron post stamped "5742 ADJ 1903"	5, 740. 882

	Feet.
Franceville, 1.2 miles northwest of, east of track, 60 feet east of telephone pole, south of second trestle, and west of road crossing under trestle; iron post stamped "5981 ADJ 1903"	5,979.962
Manitou Junction, 0.5 mile southeast of, road crossing at west gate of Richfield Springs, 50 feet west of railroad, 40 feet north of road; iron post stamped "6278 ADJ 1903"	6,277.018
Bierstadt, 500 feet west of schoolhouse, 50 feet east of Chicago, Rock Island & Pacific Ry. crossing, 40 feet north of wagon road; iron post stamped "6536 ADJ 1903"	6,534.921
Elsmere, southwest corner of stone under support at each side of water tank; bottom of square offset lettered V (Coast and Geodetic Survey bench mark)	6,420.727
Elsmere, 0.8 mile west of, corner of Tps. 13 and 14 S., Rs. 65 and 66 W., south of track, west of road; iron post stamped, "6390 ADJ 1903"	6,389.122

Falcon along roads south and east to Amo, south 12 miles, and west to Fountain.

Falcon, Colorado & Southern Ry. and Denver & Rio Grande R. R. bridge over Chicago, Rock Island & Pacific Ry. bridge, northeast end of abutment, top of stone forming third course, in first of series of steps, 5 inches northeast of Coast Survey bench mark; aluminum tablet stamped "6813 ADJ 1903"	6,812.140
Grandview, 1,000 feet west of schoolhouse, T. 13 S., Rs. 64 and 65 W., Gandry's ranch, at northwest angle of crossroads; iron post stamped "6687 ADJ 1903"	6,686.248
Amo, 3 miles west of, southwest corner of sec. 33, T. 13 S., R. 64 W.; iron post stamped "6627 ADJ 1903"	6,626.268
Amo, 40 feet west of northwest corner of sec. 1, T. 14 S., R. 64 W.; iron post stamped "6370 ADJ 1903"	6,369.411
Amo, 3 miles south of, southeast corner of sec. 14, T. 14 S., R. 64 W., on high hill, south of Kennedy's ranch; iron post stamped "6339 ADJ 1903"	6,338.375
T. 14 S., R. 64 W., southeast corner of sec. 35, 0.2 mile northeast of Ashley's ranch; iron post stamped "6125 ADJ 1903"	6,124.335
T. 15 S., R. 64 W., northeast corner of sec. 23, 2.8 miles south of Ashley's ranch, in bowlder buried 3 feet in ground; aluminum tablet stamped "5920 ADJ 1903"	5,919.189
T. 15 S., R. 64 W., southeast corner of sec. 35, 5.8 miles south of Ashley's ranch; iron post stamped "5795 ADJ 1903"	5,794.441
T. 15 S., R. 64 W., southwest corner of sec. 33, at William's ranch, on top of first high hill; iron post stamped "5787 ADJ 1903"	5,786.699
Fountain, 4 miles east of, southwest corner of sec. 36, T. 15 S., R. 65 W.; iron post stamped "5610 ADJ 1903"	5,609.554

Falcon along roads north 8 miles.

Falcon, northwest end of abutment of Colorado & Southern Ry. and Denver & Rio Grande R. R. bridge over Chicago, Rock Island & Pacific Ry., on top of stone third course of first step; bottom of square cut (Coast and Geodetic Survey bench mark)	6,812.095
Falcon, 1.5 miles north of, northeast corner of Tps. 12 and 13 S., Rs. 64 and 65 W.; iron post stamped "6971 ADJ 1903"	6,970.144
Falcon, 4.7 miles north of, 0.3 mile south of northwest corner of sec. 19, T. 12 S., R. 64 W., on summit of high bald hill east of road; iron post stamped "7306 ADJ 1903"	7,305.216

Fountain along Denver & Rio Grande R. R. to Pinyon.

	Feet.
Buttes, 1.5 miles north of, opposite Thomas Owens ranch, west of track, in field near fence corner, south of fork of road; iron post stamped "5435 ADJ 1903"	5,434.188
Buttes, 1.8 miles south of, southeast of road crossing at fence corner in field; iron post stamped "5330 ADJ 1903"	5,328.930
Wigwam, 0.2 mile north of, east of track in field near fence corner; iron post stamped "5217 ADJ 1903"	5,216.063
Wigwam, 2.2 miles north of, west of track in field, at northeast angle of fork road to Toof ranch; iron post stamped "5152 ADJ 1903"	5,150.932

Colorado Springs along Colorado Springs & Cripple Creek District Ry. to Saderlind.

Colorado Springs, east end of Huerfano Street viaduct, in coping stone of northeast corner of retaining wall, near iron post; aluminum tablet stamped "5989 COLO SP"	5,988.211
Colorado Springs, 1.1 miles west of, in coping stone 8 by 2 by 5 feet, on retaining wall 6 feet high, at back of recess 100 feet east of northeast corner of brick office building of Portland mill; aluminum tablet stamped "6101 COLO SP"	6,099.845
Colorado Springs, 3.3 miles west of, 70 feet north of track, on a sandstone bowlder 2 by 2 by 3 feet; aluminum tablet stamped "6525 COLO SP"	6,524.205
Colorado Springs, 4.3 miles west of, 60 feet west of railroad track, 1,000 feet north of cut, west side of small patch of oak brush, in sandstone bowlder 2 by 2 by 1 foot; aluminum tablet stamped "6706 COLO SP"	6,704.828
Sublime, 8 feet south of track, 300 yards west of whistling post, on bench of granite rock in a cut; aluminum tablet stamped "7299 COLO SP"	7,298.357
Fairview, 30 feet south of track on main line, 80 feet east of west end of switch, in outcropping bowlder 4 by 3 by 3 feet; bronze tablet stamped "7935 COLO SP"	7,934.347
Fairview, South Cheyenne Canyon, 2 miles west of, 12 feet north of railroad track, 100 feet east of water tank, in a granite bowlder 8 by 4 by 4 feet; aluminum tablet stamped "COLO SP 8301"	8,300.148
St. Peters, section house, 10 feet south of railroad track, in granite bowlder 14 by 8 by 4 feet; aluminum tablet stamped "8755 COLO SP"	8,754.280
Duffield, 0.2 mile west of flag station, 12 feet south of railroad track, in granite bowlder 10 by 10 by 10 feet; bronze tablet stamped "9349 COLO SP"	9,348.489
Summit, 60 feet north of railroad track, 50 feet west of post office, in outcropping granite bowlder; bronze tablet stamped "9913 COLO SP"	9,911.669
Saderlind, 100 yards west of switch, 20 feet north of track, on outcropping bowlder 3 by 5 feet, 3 feet above grade; bronze tablet stamped "9971 COLO SP"	9,969.870

Quarry Spur via Colorado Midland Ry. to Green Mountain Falls (unchecked spur line).

Manitou, in front of Colorado Midland Ry. station, top of rail	6,412.1
Manitou, Manitou Soda Spring, stone facing south side of creek, east end of bow at spring, foot of handrail post; aluminum tablet stamped "6336 1906"	6,334.657

	Feet.
Iron Springs, in front of station house; top of rail	6,522
Crags, 350 feet east of signpost, at switch; top of rail	7,004
Crags, in front of signpost; top of rail	7,015.9
Crags, 400 feet north of, north side of Fountain Creek, 100 feet north of bend of road, 20 feet west of road, in top of large round bowlder; aluminum tablet stamped "7026 1906"	7,024.888
Cascade Canyon, in front of station; top of rail	7,393.25
Cascade Canyon, southeast corner of porch of agent's house; iron post stamped "7391 1906"	7,390.111
Culver, in front of signpost; top of rail	7,482.9

Colorado Springs south along road via Lytle to Turkey Creek, thence east to Wigwam.

Colorado Springs, 3.6 miles south of, 10 feet east of gate of Cheyenne Mountain ranch, 6 feet from fence; iron post stamped "6087 1906." (This bench mark has been moved S. 89° W. 30 feet, but the elevation is not changed)	6,087.266
Colorado Springs, 6.5 miles south of, south edge of Little Pass, east edge of road, in top of bowlder; aluminum tablet stamped "5955 1906"	5,954.429
Colorado Springs, 8.4 miles south of, road corner, north side of little knoll, opposite fence corner; iron post stamped "5847 1906"	5,846.520
Colorado Springs, 12.4 miles south of, 0.7 miles east of Hake's ranch, south edge of road, in flat surface of 1.5-foot rock, in pile; aluminum tablet stamped "6104 1906"	6,103.221
Deadmans Canyon, 0.5 mile above ranch house, 15 feet east of pine tree on side of drain, east of dugout cabin, 20 feet west of road; iron post stamped "6393 1906"	6,392.204
Lawton's ranch, 1.5 miles south of, 800 feet south of road corner, 10 feet north of pine tree east of road, beside fence, in sandstone; aluminum tablet stamped "6381 1906"	6,380.310
Lytle, 1.4 miles south of schoolhouse, summit of hill east of Turkey Creek, in bowlder; aluminum tablet stamped "6170 1906"	6,169.173
Lytle, 4.5 miles south of schoolhouse, 200 feet north of gate leading to ranch on creek, east side of road, beside fence; iron post stamped "5990 1906"	5,989.262
Lytle, 7.6 miles south of schoolhouse, edge of bluff at head of small canyon, 10 feet west of road; iron post stamped "5911 1906"	5,910.194
Greenley's ranch, 1 mile east of, on line with lone poplar, edge of drain, and lone pine tree, on sandy point, 10 feet west of old road; iron post stamped "5451 1906"	5,450.500
Greenley's ranch, 4.4 miles east of, 1,000 feet northeast of cottonwood tree by creek, 0.4 mile west of spring, 10 feet north of old road; iron post stamped "5305 1906"	5,304.390
Wigwam, 0.3 mile north of station, 30 feet east of Denver & Rio Grande R. R. tracks, at corner fence post; iron post stamped "5217"	5,216.073

CASTLE ROCK QUADRANGLE.

Point 7.5 miles north of Falcon to Husted.

Falcon, 7.5 miles north of, southwest corner of Tps. 11 and 12 S., Rs. 64 and 65 W., in Myer pasture, 2 feet west of fence corner; iron post stamped "7524 ADJ 1903"	7.523.146

	Feet.
T. 11 S., R. 65 W., in center of sec. 34, at K. K. ranch-house gate, 6 feet west of fence and 10 feet south of shed, in sandstone slab; aluminum tablet stamped "7559 ADJ 1903"	7,558.433
T. 11 S., R. 65 W., at southwest corner of sec. 32, west of road, in McBroom's pasture, 20 feet west of fence; iron post stamped "7629 ADJ 1903"	7,628.296
T. 11 S., R. 66 W., 300 feet east of northwest corner of sec. 36, in 6 by 10 by 4 foot sandstone slab, at Sam Brown's ranch gate; aluminum tablet stamped "7505 ADJ 1903"	7,504.725
Stout ranch, 800 feet north of, in southwest angle of crossroads, in side fence; iron post stamped "7153 ADJ 1903"	7,152.460
Husted, 0.5 mile west of Denver & Rio Grande R. R. station, in southeast angle of forks of roads, inside fence in pasture; iron post stamped "6663 ADJ 1903"	6,662.343
Husted, 1.2 miles south of, opposite E. P. Moon's house, second step from top of north abutment of bridge 63 A; bottom of square (Coast and Geodetic Survey bench mark)	6,516.817

PIKES PEAK SPECIAL QUADRANGLE.

Manitou northwest along Manitou & Pikes Peak Ry. (cog-wheel road) to Pikes Peak, thence west to Clyde (unadjusted line closing 2 feet high).

Manitou, Manitou & Pikes Peak Ry. station, 7 feet from east side, 50 feet west of entrance, in face of wall; aluminum tablet stamped "6571"	6,570.333
Manitou, 2 miles west of, north side of track, 75 feet east of section house at Minnehaha, in face of rock; aluminum tablet stamped "8332"	8,331.881
Manitou, 2.6 miles north of, on top of small rise west and about 300 feet north of Halfway House, north side of track, in rock; aluminum tablet stamped "9010"	9,010.290
Manitou, 4.7 miles west of, south side of track, 100 feet south of "Gulch Tank," in bowlder; aluminum tablet stamped "10012"	10,012.115
Manitou, 5.8 miles north of, west side of track, 0.5 mile west of "Grecian Bend," in large bowlder; aluminum tablet stamped "11005"	11,005.898
Manitou, 6 miles west of, at west side entrance of Windy Point House; aluminum tablet stamped "12129"	12,130.138
Manitou, 8 miles west of, east side of track, 1 mile south of summit of Pikes Peak, in ledge of rock; aluminum tablet stamped "13006"	13,006.937
Manitou, 9 miles west of, main entrance to sleeping apartment of Summit House on top of Pikes Peak, in water table; aluminum tablet stamped "14084 1906–7"	14,085.330
Pikes Peak, 500 feet west of Summit House, in bowlder 5 by 6 feet situated on the very top of Pikes Peak; aluminum tablet stamped "14109"	14,108.873
Pikes Peak, 500 feet west of Summit House, in side of bowlder on summit, aluminum plate 4.8 inches wide and 7.1 inches long, engraved as follows: "U. S. Geological Survey, George Otis Smith, Director, PIKES PEAK, Latitude 38° 50′ 26″, Longitude 105° 02′ 37″, U. S. Standard, Elevation above sea 14109 feet, 1908."	
Pikes Peak, in monument of rocks on summit of Pikes Peak; aluminum tablet stamped "14107 1906–7"	14,109.069

	Feet.
Windy Point, 3 miles south of, 400 yards north of Dam No. 4, at Seven Lakes, 100 yards south of forks of roads, east side of road, in bowlder 4 by 5 feet; aluminum tablet stamped "10902"	10,902.707
Windy Point, 6 miles south of, 1.5 miles north of Clyde, 150 feet above and east of creek, 200 yards east of prominent cliff, west side of road, in bowlder 5 by 6 feet; aluminum tablet stamped "9983"	9,983.136

Saderlind to Love.

Saderlind, 3.6 miles west of, 10 feet northeast of railroad track, 200 yards west of milepost 28, at east end of cut, on bench of granite rock, 3 feet above rail; bronze tablet stamped "9631 COLO SP"	9,630.302
Clyde, 0.6 mile west of station, 10 feet northeast of track, 300 yards west of Colorado Springs & Cripple Creek District Ry. tunnel, in granite bowlder 10 by 3 by 3 feet; aluminum tablet stamped "9385 COLO SP"	9,384.423
Love, 0.2 mile west of station, in a cut 15 feet south of track, in granite ledge; aluminum tablet stamped "COLO SP 9693"	9,692.089

Cripple Creek special quadrangle.

TELLER COUNTY.

The elevations in the following list are based on an aluminum tablet stamped "9494 C C" in the south wall of the National Hotel, Cripple Creek, the height of which is accepted as 9,493.119 feet above mean sea level in accordance with the preliminary 1911 adjustment by the Coast and Geodetic Survey.

The leveling was done in 1904 by M. S. Bright.

CRIPPLE CREEK SPECIAL QUADRANGLE.

Circuits in Cripple Creek.

	Feet.
Cripple Creek, opposite Midland Terminal Ry. station; top of rail	9,517.8
Cripple Creek, southwest corner of city hall; city bench mark	9,493.534
Cripple Creek, National Hotel, 3 feet west of south entrance, in stone foundation; aluminum tablet stamped "9494 C C"	9,493.119
Cripple Creek, Teller County jail, in east end of stone doorsill, north entrance; aluminum tablet stamped "9508 C C"	9,507.529

Cripple Creek northwest and north via Red Mountain up Spring Creek to pipe line, thence south via Hoosier Pass, Vista Grande, Windy Point, Elk, and Anaconda to Cripple Creek.

Cripple Creek, 1.5 miles northwest of, on saddle at northeast foot of Mount Pisgah, 40 feet north of road forks, near line of telegraph poles, in granite outcrop; aluminum tablet stamped "9454 C C"	9,453.423
Standard tunnel, 0.2 mile south of, 10 feet north of road, 50 feet north of Spring Creek, in rock outcrop; aluminum tablet stamped "9328 C C"	9,325.911
Standard tunnel, at mouth; top of east rail	9,522.9

	Feet.
Midway dairy, 120 feet north of road, in rock outcrop; aluminum tablet stamped "9817 C C"	9,814.798
Midway dairy, 1 mile east of, 1 mile south of Lincoln mine, 50 feet east of pipe line, in triangle of roads; iron post stamped "10088 C C"	10,085.694
Hoosier Pass, between main line of Colorado Springs & Cripple Creek District Ry. and siding, 12 feet west of public road between two posts supporting Hoosier Pass signboard; iron post stamped "10315 C C"	10,312.726
Vista Grande (Midway station), 13 feet west of, near Florence & Cripple Creek R. R. track, 1 foot south of signpost "Vista Grande"; iron post stamped "10487 C C"	10,484.732
Elkton, in south corner of stone foundation of south stack of Elkton Consolidated Mining & Milling Co.; aluminum tablet stamped "9734 C C"	9,731.736
Anaconda, 400 feet south of Midland Terminal Ry. station, 6 feet east of track, in wall of rock cut; aluminum tablet stamped "9525 C C"	9,522.799
Anaconda, 1 mile northwest of, 450 feet north of World's Fair, 8 feet west of Midland Terminal Ry. track, in granite outcrop; aluminum tablet stamped "9534 C C"	9,532.017

Head of Spring Creek via Gillett, Victor Pass, and Goldfield to Elkton.

Gillett, 1.2 miles west of, 600 feet south of Lincoln mine, 20 feet west of road forks, in phonite rock outcrop; aluminum tablet stamped "10021 C C"	10,019.113
Gillett, in stone foundation of electric light plant, in west wall, 1 foot north of southwest corner; aluminum tablet stamped "9940 C C"	9,937.725
Gillett, in front of Midland Terminal Ry. station; top of rail	9,932.3
Cameron, 2 miles east of, 100 feet south of milepost 17, in granite wall 8 feet west of Midland Terminal Ry. track; aluminum tablet stamped "9841 C C"	9,838.735
Cripple Creek Sampler & Ore Co., 425 feet east of, in Victor Pass, 12 feet south of Midland Terminal Ry. track, 1 foot east of telephone pole; iron post stamped "10202 C C"	10,199.959
Goldfield, north side of Ninth Street, between Main and Portland streets, entrance to Red Men's Hall, in west end of stone doorsill; aluminum tablet stamped "9903 C C"	9,901.180

Goldfield to Victor along railroad.

Goldfield, in front of Florence & Cripple Creek R. R. station; top of rail	9,880.8
Stratton Junction; top of railroad frog	9,807.1
Victor, in front of Colorado Springs & Cripple Creek District Ry. station; top of rail	9,705.7
Victor, Trading & Trust Co. building, northeast corner of Diamond Avenue and Third Street, in north end of stone doorsill; bronze tablet stamped "9718 C C"	9,715.731
Victor, in front of Florence & Cripple Creek R. R. station; top of rail	9,272.4
Victor, in front of Midland Terminal Ry. station; top of rail	9,769.8

World's Fair mine No. 50, Anaconda, southwest down Cripple Creek along third-class road and west to Pony Gulch, thence north-northeast to Cripple Creek.

	Feet.
Mount, 0.5 mile southwest of, west side of Cripple Creek, 200 feet south of road, in granite outcrop; aluminum tablet stamped "9232 C C"	9, 229. 820
Field's ranch, 0.8 mile southwest of, 200 feet east of road forks, on saddle, south side of Dead Ox Gulch, in granite outcrop; aluminum tablet stamped "9133 C C"	9, 130. 587
Arlington dairy, 2,000 feet north of, west side of Pony Gulch, east edge of road, in granite outcrop; aluminum tablet stamped "9113 C C"	9, 110. 835
Cripple Creek, 1.2 miles south of, 700 feet north of powder magazines, at road forks, in granite outcrop; bronze tablet stamped "9393 C C"	9, 390. 857

Apishapa, Nepesta, and Pueblo quadrangles.

LAS ANIMAS, OTERO, AND PUEBLO COUNTIES.

The elevations in the following list are determined by primary leveling extended from Colorado Springs. The lines southeast from Pueblo were originally based upon an elevation at Pueblo determined from leveling of the Denver & Rio Grande Railroad, corrected to accord with the 1906 accepted height of a bench mark at Colorado Springs. The values here given, however, result from a double connection by the U. S. Geological Survey in 1911, and accord with the preliminary 1911 adjustment of the Coast and Geodetic Survey. Orthometric corrections have also been applied, increasing the instrumental values cumulatively toward the south.

The leveling was done in 1896 by J. C. Barber, except that on the line from Pinyon to Pueblo, which was done in 1905 by C. I. Anderson, and the connection at Pueblo in 1911 by C. P. Gross.

PUEBLO QUADRANGLE.

Pinyon along Denver & Rio Grande Ry. to Pueblo.[1]

	Feet.
Pinyon, 0.7 mile south of, east track, in field at fence corner, at north boundary of M. S. Sutherland's ranch; iron post stamped "5045 ADJ 1903"	5, 044. 050
Pinyon, 2.5 miles south of, west of track, northwest of road crossing, opposite Sam Link's ranch house, inside field; iron post stamped "4962 ADJ 1903"	4, 961. 274
Eden, 0.5 mile north of, west of road, inside field at fence corner; iron post stamped "4901 ADJ 1903"	4, 900. 167
Pueblo, 3 miles north of, 6 feet north of gate at J. W. Craig's milk ranch; iron post stamped "4782 ADJ 1903"	4, 781. 250
Pueblo, 4 feet north of west entrance of Centennial schoolhouse, in brownstone water table; aluminum tablet stamped "4708 ADJ 1903" (set vertically)	4, 707. 310

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[1] This line is based on Coast and Geodetic Survey bench marks at Colorado Springs, and is checked by two runnings.

	Feet.
Pueblo, 5 feet south of west entrance of Centennial schoolhouse; square cut on northwest corner of sandstone step leading to basement	4,703.869

Pueblo east along Atchison, Topeka & Santa Fe Ry. to Baxter.

Pueblo, 12 feet west of northeast corner of courthouse; bronze tablet stamped "6490"	4,694.500
Pueblo, Grand Opera House, 20 feet west of northeast corner; bronze tablet stamped "4665"	4,669.107
Pueblo, north side of main entrance to city hall; cross on lintel	4,661.09
Baxter, 720 feet west of, between tracks of Atchison, Topeka & Santa Fe Ry. and the Missouri Pacific Ry.; iron post stamped "4624"	4,628.427

NEPESTA QUADRANGLE.

Baxter east along Atchison, Topeka & Santa Fe Ry. to Fowler.

Chico, 1,000 feet east of railroad station, between Atchison, Topeka & Santa Fe Ry. and Missouri Pacific Ry. tracks; iron post stamped "4540"	4,544.927
Boone, 2,500 feet west of Missouri Pacific Ry. station, 300 feet east of Atchison, Topeka & Santa Fe. Ry. milepost 599, and 52 feet north of Atchison, Topeka & Santa Fe Ry. tracks; iron post stamped "4477"	4,481.383
Boone, in front of Missouri Pacific Ry. telegraph office; top of rail	4,470.7
Nepesta, 3.5 miles west of, 50 feet west of center of private road, on property line between Atchison, Topeka & Santa Fe Ry. and Missouri Pacific Ry.; iron post stamped "4405"	4,409.281
Nepesta, NW. ¼ sec. 32, T. 21 S., R. 60 W., Atchison, Topeka & Santa Fe Ry. bridge across Arkansas River; 5 feet below capstone, 15 feet above bed of river channel, east end of north pier; bronze tablet stamped "4368"	4,372.310
Fowler, 3 miles west of, NW. ¼ sec. 12, T. 22 S., R. 60 W., 5 feet south of corner fence post at angle in county road 600 feet south of Arkansas River, 150 feet south of railroad tracks; iron post stamped "4343"	4,347.152
Fowler, SE. ¼ sec. 17, T. 22 S., R. 59 W., 1,200 feet west of railroad station, 48 feet south of Atchison, Topeka & Santa Fe Ry. tracks; iron post stamped "4331"	4,335.377

Boone via Rattlesnake Buttes to Huerfano.

Boone, 2.2 miles southwest of, midway between road on west side of Huerfano River and edge of bluff bordering marsh, 200 feet south of bend in road, 500 feet south of row of six trees in pasture; copper nail in root of cottonwood tree	4,475.66
Boone, 3 miles southwest of, 0.2 mile northwest of river, 0.5 mile east and slightly north of log hut at foot of mesa, 0.8 mile northeast of residence, 900 feet north of graveyard on roadside; wire nail in root of double cottonwood tree alone in pasture	4,495.66
Boone, 4.2 miles southwest of, at side of abandoned irrigation ditch, 0.8 mile southwest of adobe residence and brick building; spike in cottonwood tree at north end of row of four	4,517.13
Boone, 5 miles southwest of, 17 feet south of east quarter corner of sec. 27, T. 21 S., R. 62 W.; iron post stamped "4532"	4,536.385

	Feet.
Boone, 6 miles southwest of, 700 feet east of residence at foot of hill, 100 feet west of river bank; spike in root of tallest of a bunch of four cottonwood trees	4, 552. 88
Boone, 10 miles southwest of, 30 feet east of west quarter corner of sec. 19, T. 22 S., R. 62 W.; iron post stamped "4699"	4, 703. 638
Huerfano Bridge, sec. 8, T. 23 S., R. 63 W., capstone south pier, west end of; copper bolt stamped "U. S. G. S. 4774 Ft. B. M."	4, 778. 927

NE. ¼ sec. 29, T. 23 S., R. 59 W., to Fowler.

T. 23 S., R. 59 W., NE. ¼ sec. 29, 800 feet west of road, 1 mile west of Apishapa River, on top of knoll S. 26° W. from northernmost of a group of three buttes on opposite side of river; iron post stamped "4449"	4, 453. 508
Fowler, 4 miles south of, SW. ¼ sec. 4, T. 23 S., R. 59 W., 0.5 mile west of river, 255 feet east of road; iron post stamped "4432"	4, 436. 456

Doyle's ranch to Butler's pasture.

Huerfano Bridge, 1.8 miles southwest of, 75 feet east of Huerfano River, 35 feet west of foot of bluff 80 feet high, 0.5 mile south of residence in Peck's pasture; spike in cottonwood tree 3 feet in diameter	4, 814. 15
Butler's pasture, 0.8 mile southwest of Pressley's house, 250 feet east of Huerfano River, 40 feet east of abandoned irrigation trench; chiseled cross and circle on rock 2 by 3 feet	4, 889. 96
T. 23 S., R. 63 W., northeast corner of sec. 28, 15 feet south of stone, 0.8 mile northeast of Pressley's house, 500 feet southeast of edge of bank of Huerfano River, 0.2 mile east of Mexican's house on opposite side of river, 0.2 mile west of bluff; iron post stamped "4863"	4, 867. 515

Huerfano Bridge to Rattlesnake Buttes (portion of line).

T. 23 S., R. 63 W., sec. 31, 4 miles southeast of Huerfano Bridge, 0.8 mile northwest of Mexican's residence, 20 feet north of gate in east-west fence; iron post stamped "4958"	4, 962. 550

APISHAPA QUADRANGLE.

Butler's pasture southwest to sec. 5, T. 24 S., R. 63 W.

T. 24 S., R. 63 W., east side of sec. 5, 250 feet from gate in east-west wire fence; copper bolt in west end of rock 20 by 12 by 2.5 feet, marked "U. S. G. S. 5019 Ft. B. M."	5, 023. 622

Huerfano Bridge to Rattlesnake Buttes (portion of line).

T. 24 S., R. 62 W., NW. ¼ sec. 19, 35 feet west of road, 4 feet east of wire fence, 150 feet north of gate; iron post stamped "5074"	5, 078. 555
Hog Ranch Canyon, 0.8 mile south of mouth of, 100 feet east of road, 75 feet west of Doyle's Arroyo, 60 feet south of north end of stone ledge; chiseled cross on rock	5, 183. 82
T. 24 S., R. 63 W., SW. ¼ sec. 25, 200 feet southwest of road, 1,000 feet north of mouth of Hog Ranch Canyon; iron post stamped "5194"	5, 198. 555
Hog Ranch Canyon, 1.8 miles southwest of crossing, 800 feet east of road, 8 inches above ground, south side of depression; chiseled cross mark on rock	5, 328. 48
T. 25 S., R. 63 W., SE. ¼ sec. 10, 3 miles north of south edge of Butler's pasture, 40 feet east of road, 0.2 mile west of canyon; iron post stamped "5514"	5, 518. 537

	Feet.
Butler's pasture, 2.8 miles north of south edge, 150 feet west of road, eastern of four flat rocks; chiseled cross mark on top of, 1 foot from ground	5,574.56
Butler's pasture, 0.5 mile north of south side, 15 feet west of road crossing long ledge on south side of clearing; chiseled cross 1 foot south of large pine tree	5,679.66
T. 25 S., R. 63 W., NW. ¼ sec. 34, 300 feet southwest of gate in south fence of Butler's pasture, 150 feet west of road to Cucharas Junction, 15 feet northeast of tree; copper bolt in top of flat rock, stamped "U. S. G. S. 5742 Ft. B. M."	5,747.084
T. 26 S., R. 63 W., NE. ¼ sec. 10, 2.5 miles southeast of gate in south fence of Butler's pasture, 30 feet east of road; iron post stamped "5927"	5,931.632

Rattlesnake Buttes to Apishapa Ford.

Rattlesnake Buttes, 0.8 mile east of, SW. ¼ sec. 22, T. 26 S., R. 63 W., 50 feet northeast of crossroads; iron post stamped "6184"	6,188.61
Rattlesnake Buttes crossroads, 2 miles east of, 400 feet north of road; chiseled cross on stone 8 inches high, 4 feet west of the highest of a group of six	6,095.96
Rattlesnake Buttes crossroads, 3 miles east of, NW. ¼ sec. 19, T. 26 S., R. 62 W., 50 feet north of road; iron post stamped "6009"	6,013.703
Rattlesnake Buttes crossroads, 6.2 miles east of, SW. ¼ sec. 15, T. 26 S., R. 62 W., 0.2 mile east of head of canyon, 300 feet north of road; copper bolt in rock 4 by 6 feet, 8 inches high, marked "U. S. G. S. 5735 Ft. B. M."	5,739.558
Rattlesnake Buttes crossroads, 7.8 miles east of, 50 feet north of road, large rock, 2 feet high, split on top; cross on south end	5,618.66
Rattlesnake Buttes crossroads, 8.2 miles east of, 35 feet south of road, southeast edge of a group of a dozen rocks; chiseled cross on northeast side of rock, 6 by 6 feet, 2.5 feet high	5,566.47
Rattlesnake Buttes crossroads, 10 miles east of, south side of sec. 18, T. 26 S., R. 61 W., 650 feet north of road, on west side of group of large rocks about 8 feet high; copper bolt in east end of rock 6 by 10 feet, 2.5 feet high, marked "U. S. G. S. 5444 Ft. B. M."	5,448.675
Apishapa Ford, 6.2 miles west of, 0.2 mile south of road, 150 feet south of ravine, 80 feet east of dead cedar tree, on southeast side of small knoll bearing several cedar trees; chiseled cross on light rock	5,300.24
Apishapa Ford, 5½ miles west of, SW. ¼ sec. 15, T. 26 S., R. 61 W., 2,000 feet south of road, 1,000 feet south of Buffalo Arroyo, on north side of rock outcrop covered with cedars and pines, 100 feet west of tree on northeast corner of group; copper bolt in light sandstone rock 15 by 8 feet, 4 feet high; marked "U. S. G. S. 5215 Ft. B. M."	5,219.658
Buffalo Arroyo, north bank, near mouth of canyon, 20 feet north of bushy cedar tree, the third on north bank from road crossing below; chiseled cross on light stone 3 by 1½ feet, 1 foot high	5,041.29
Apishapa Ford, 2.8 miles west of, SE. ¼ sec. 13, T. 26 S., R. 61 W., 2,000 feet southeast of road crossing over Buffalo Arroyo, 1,000 feet south of road; rock outcrop covered with cedars and cactus, 150 feet southwest of northeast corner; copper bolt in rock 25 by 12 by 4 feet, stamped "U. S. G. S. 4929 Ft. B. M."	4,933.646

	Feet.
Apishapa Ford, 1,000 feet northeast of, NW. ¼ sec. 21, T. 26 S., R. 60 W., 250 feet southwest of road; bronze tablet in largest rock of group near center of small knoll, stamped "4814"	4,818.618

Apishapa Canyon north to southwest corner of sec. 5, T. 24 S., R. 59 W.

Apishapa Ford, 3.5 miles northeast of, NE. ¼ sec. 3, T. 26 S., R. 60 W., near mouth of canyon, 0.5 mile west of river, on narrow east-west ridge, 200 feet west of road; iron post stamped "4734"	4,738.72
T. 25 S., R. 60 W., NW. ¼ sec. 25, 1.8 miles north of adobe house, 1.5 miles south of road crossing over Sanders Arroyo, 0.8 mile west of river, 35 feet west of road; iron post stamped "4664"	4,668.733
Sanders Arroyo, 100 feet west of mouth of, 100 feet west of river; large wire nail 5 feet above ground, in crotch of cottonwood tree	4,618.60
T. 25 S., R. 59 W., SW. ¼ sec. 5, 10 feet east of corner stone at southwest corner of section 5; iron post stamped "4605"	4,609.436
T. 24 S., R. 59 W., 20 feet southwest of northeast corner of sec. 30; iron post stamped "4600"	4,604.438
T. 24 S., R. 59 W., 1,700 feet south of northeast corner of sec 19, west side of knoll; chiseled cross on small stone	4,611.02
T. 24 S., R. 59 W., southwest corner of sec. 5, on top of ridge, 0.8 mile west of road, 1 mile south of Mustang Creek, 1 mile S. 84° W. of lake; iron post stamped "4487"	4,491.513

Doyles Arroyo to Mustang Creek.

T. 24 S., R. 62 W., north side of sec. 25, 1.8 miles northwest of dwelling house in Gilpen pasture, 30 feet southwest of road to Pueblo; iron post stamped "4958"	4,962.689
T. 24 S., R. 61 W., east side of sec. 29, 1.5 miles east of dwelling in Gilpen pasture, 60 feet south of Fowler-Cucharas road; iron post stamped "4836"	4,840.654
T. 24 S., R. 61 W., west side of sec. 24, 5 miles east of Gilpen residence, 1 mile northwest of house on Yellowbank ranch, 30 feet southeast of road from Fowler to Cucharas; iron post stamped "4695"	4,699.596
T. 24 S., R. 60 W., NE. ¼ sec. 17, 0.6 miles southeast of Mustang Creek, 0.6 mile west of east side of John Rensselaer's pasture; iron post stamped "4617"	4,621.398
T. 24 S., R. 60 W., SE. ¼ sec. 10, 1.5 miles east of east edge of John Rensselaer's pasture, 0.4 mile south of Mustang Creek, 100 yards south of edge of sagebrush; iron post stamped "4560"	4,564.375

Gilpen pasture to Sanders Arroyo.

T. 25 S., R. 62 W., SE. ¼ sec. 3, 3.5 miles southwest of house in Gilpen pasture, 20 feet west of road to Cucharas, at gate in west fence of pasture; iron post stamped "5026"	5,030.7
T. 25 S., R. 62 W., center of sec. 14, 30 feet northeast of gate on southeast side of the Jim Peck pasture, 0.2 mile southwest of Gilpen pasture; iron post stamped "5055"	5,059.677
T. 25 S., R. 61 W., south side of sec. 16, 0.5 mile west of wire fence on east side of Gilpen pasture; iron post stamped "5012"	5,016.655

	Feet.
T. 25 S., R. 61 W., NW. ¼ sec. 13, 2.8 miles east of the Twin Tepee Buttes, 0.8 mile northwest of Yellowbank ranch, on east side of Sanders Arroyo, 1,000 feet northwest of small arroyo heading at Twin Tepee Buttes, on top of slight divide; iron post stamped "4860"	4,864.695
T. 25 S., R. 60 W., NW. ¼ sec. 16, 5.8 miles east of Twin Tepee Buttes, 0.5 mile north of Sanders Arroyo, on edge of sagebrush; iron post stamped "4749"	4,753.542

Apishapa Ford to Thatcher.

Apishapa Ford, 0.8 mile south of, 20 feet from south end and 40 feet from west edge of long rocky stream bed running northeast; chiseled cross and circle on rock	4,870.53
Apishapa Ford, 4.5 miles southeast of, T. 27 S., R. 60 W., SE. ¼ sec. 3, 0.2 mile southwest of foot of range of Sawtooth Hills, 0.5 mile west of corner of ridge; iron post stamped "5117"	5,121.722
T. 27 S., R. 60 W., south side of sec. 36, 1,000 feet south of head of Christian Canyon, 45 feet east of wagon road, rock 6 by 10 by 2.5 feet high, at north end of a group of dome-shaped light sandstone rocks; copper bolt in north end marked "U. S. G. S. 5164 Ft. B. M."	5,168.755
T. 28 S., R. 60 W., NE. ¼ sec. 13, 2.8 miles south of head of Christian Canyon, 30 feet east of road; iron post stamped "5270"	5,274.842
Thatcher, 1.5 miles north of station, T. 28 S., R. 60 W., south side of sec. 27, 700 feet west of road, 300 feet south of rocky arroyo, 130 feet east of a cedar tree, in top of south end of light sandstone rock 1.5 feet high; copper bolt marked "5360 Ft. B. M."	5,364.896
Thatcher, 0.2 mile southwest of railroad station, T. 29 S., R. 60 W., SE. ¼ sec. 4, on southeast edge of group of rocks at east end of loose rock dam across Timpas Creek; copper bolt in northwest end of rock 20 by 12 by 3 feet, marked "U. S. G. S. 5398 Ft. B. M."	5,402.863

Thatcher to Rattlesnake Buttes.

Thatcher, 2 miles west of, 130 feet south of road; large wire nail near ground in crotch of half-dead cedar tree	5,556.97
Thatcher, 3.2 miles west of, on top of mesa, 300 feet north of road; nail in south side of cedar stump	5,687.91
Thatcher, 4.5 miles northwest of, T. 28 S., R. 61 W., east side of sec. 35, 500 feet north of lake, 40 feet north of road; iron post stamped "5736"	5,740.966
Apishapa Ford, 1.8 miles southeast of, at head of canyon, 100 feet north of road, 300 feet northwest of prospecting hole; wire nail in root of solitary cedar tree	5,532.09
Apishapa Ford, 1.2 miles southeast of, 30 feet northeast of road near east edge of cedar ridge; wire nail in cedar snag	5,456.51
Apishapa Ford, NE. ¼ sec. 20, T. 28 S., R. 61 W., 300 feet northwest of, 350 feet north of old corral, 1,000 feet north of Smith's abandoned adobe house, at head of main canyon of the Apishapa River; copper bolt in rock 30 by 30 by 4 feet, 12 ft. north of edge, marked "U. S. G. S. 5331 Ft. B. M."	5,335.835

	Feet.
Apishapa Ford, 2 miles northwest of, 30 feet north of road, 200 feet east of rock outcrop crossing road; chiseled cross on stone 3 by 3 by 1 foot	5,469.01
Apishapa Ford, NW. ¼ sec. 14, T. 28 S., R. 62 W., 3.5 miles northwest of, 300 feet north of road, 800 feet south of timbered ridge, 1,000 feet northwest of small outcropping dike, 30 feet from west end of rock 120 by 20 feet, 3 feet high in center; copper bolt marked "U. S. G. S. 5548 Ft. B. M."	5,552.949
T. 28 S., R. 62 W., west side of sec. 7, 1.5 miles north of cedar bluffs, near southwest corner of a ledge on north side of a prominent draw, pile of small stone on top of rock, in south side of a flat sandstone rock 1 foot above ground; copper bolt marked "U. S. G. S. 5756 Ft. B. M."	5,760.804
T. 27 S., R. 63 W., NE. ¼ sec. 33, 8 miles south of Rattlesnake Buttes, 0.8 mile east of crossroads, 0.5 mile northwest of abandoned cabin and corral, near dripping springs, 100 feet north of arroyo emptying in dripping spring, 50 feet north of a similar rock 12 by 25 by 6 feet high; copper bolt 8 inches above ground in light rock at east end of a black rock, 8 by 14 by 6 feet, marked "U. S. G. S. 5941 Ft. B. M."	5,945.875
T. 27 S., R. 63 W., SW. ¼ sec. 16, 4.2 miles south of South Rattlesnake Butte, 300 feet northwest of road, 300 feet southeast of arroyo, 1,000 feet west of head of canyon, in southeast corner of dark rock, 25 by 10 by 10 feet, near north side of group, 150 by 300 feet; copper bolt, 15 inches from ground, marked "U. S. G. S. 5924 Ft. B. M."	5,929.063
Rattlesnake Buttes crossroads, 4 miles south of, 30 feet east of road, 2 feet north of forked cedar tree; chiseled cross on stone	6,010.55

Point near Dripping Spring (8 miles south of Rattlesnake Buttes) south and east to head of Apishapa Canyon.

T. 28 S., R. 63 W., center of sec. 9, 10 miles south of Rattlesnake Buttes, 2.5 miles south of crossroads, 900 feet east of north-south wagon road, 20 feet northeast of a pile of loose rock 5 feet high, in black rock, 5 by 5 by 1 foot; copper bolt marked "U. S. G. S. 5930 Ft. B. M."	5,934.785
T. 28 S., R. 63 W., SE. ¼ sec. 21, 1.2 miles southwest of windmill, 1,000 feet west of road, 2,000 feet southeast of an arroyo, 100 feet northeast of foot of cedar bluffs, 300 feet east of a large slabbed rock, 20 by 8 by 4 feet, half way up the side of bluff, northwest side of group, in top of rock, 3 by 7 by 1 foot; copper bolt marked "U. S. G. S. 5957 Ft. B. M."	5,961.774
T. 29 S., R. 63 W. SW. ¼ sec. 4, 16 miles south of Rattlesnake Buttes, 2.2 miles west of Black Summit Butte, in gap on divide, 800 feet wide, 300 feet northeast of small dome-shaped butte, 50 feet east of road, 60 feet west of edge of timber; iron post stamped "6224"	6,228.659
T. 29 S., R. 62 W., NE. ¼ sec. 1, 3.2 miles southwest of abandoned adobe house, at head of Apishapa Canyon, 0.8 mile northwest of Apishapa River, top of hill 20 feet high, on east face; iron post stamped "5505"	5,509.861

Head of Apishapa Canyon northwest to Rattlesnake Buttes.

Apishapa Canyon, 5 miles northwest of head of, 70 feet east of road, 0.5 mile north of arroyo; wire nail in base of solitary cedar tree	5,462.30

	Feet.
T. 27 S., R. 62 W., north side of sec. 34, east of road, 100 feet east of arroyo, 150 feet northwest of northwest corner of rocky ledge on northeast side of arroyo, triangular-shaped knoll, 100 feet on sides, 15 feet high on west side, 20 feet north of south corner; copper bolt marked "U. S. G. S. 5435 Ft. B. M."	5,439.670
T. 27 S., R. 62 W., east side of sec. 24, on southeast side of a prairie ridge, 1.5 miles northwest of cedar ridge, 1 mile southeast of canyon, 20 feet south of north side of group of rock, in center of row of six cedar trees, in top of sandstone rock, 12 by 10 by 2 feet; copper bolt marked "U. S. G. S. 5471 Ft. B. M."	5,475.850
T. 27 S., R. 62 W., SW. ¼ sec 6, 2.5 miles south of Sanche Lake, 1,400 feet west of road, 400 feet north of arroyo, 100 feet northeast of solitary cedar tree, in west end of sandstone ledge, 45 by 6 by 5 feet high, vertical on south face; copper bolt marked "U. S. G. S. 5855 Ft. B. M."	5,860.13

Apishapa Ford east, south, and west to Thatcher.

T. 26 S., R. 59 W., NE. ¼ sec. 19, 4.5 miles east of ford at mouth of of Apishapa Canyon, 0.5 mile south and slightly east of lake, 30 feet south of road, 0.5 mile west of range of yellow hills; iron post stamped "4877"	4,881.998
T. 27 S., R. 59 W., center of sec. 7, 5.2 miles south of lake, 300 feet southwest of bluffs, 1 mile southeast of southwest corner of bluffs, on top of slight ridge, 30 feet from solitary cedar tree; iron post marked "5166"	5,170.774
T. 28 S., R. 59 W., NW. ¼ sec. 20, 5.5 miles northeast of Thatcher, 600 feet southwest of southwest end of pile bridge 62, 65 feet southeast of Atchison, Topeka & Santa Fe Ry. tracks; iron post stamped "5141"	5,145.763
Thatcher, 4.5 miles east of, east side of sec. 5, T. 29 S., R. 59 W., 1,800 feet northwest of cabin, 450 feet south of wagon road, 1,000 feet west of arroyo, 600 feet south of branch arroyo; iron post stamped "5345"	5,349.738
Thatcher, 2. 2 miles east of, 500 feet northwest of Sugar Loaf Butte, 100 feet north of road, on southeast side of timber, large wire nail in pinyon tree	5,480.43
Thatcher, 4.8 miles southwest of, southwest corner of sec. 24, T. 29 S., R. 61 W., 1.4 miles northwest of Atchison, Topeka & Santa Fe Ry. tracks, 40 feet north of wagon road; iron post stamped "5612"	5,616.781

Breckenridge special quadrangle.

SUMMIT COUNTY.

The elevations in the following list depend on the heights of a precise-level bench mark at Braddock.

The leveling was done by C. H. Semper in 1908.

BRECKENRIDGE SPECIAL QUADRANGLE.

Braddock via Swan City to Breckenridge.

	Feet.
Braddock, 90 feet south of signboard, 15 feet west of railroad track, in top of granite bowlder; aluminum tablet stamped "9242"	9,241.435

	Feet.
Braddock, 3.44 miles east of, 4 feet south of road at small stream crossing road, in top of granite bowlder; aluminum tablet stamped "9489"	9,488.886
Swan City, 55 feet north of road, 100 feet east of cabin at east end of broken-down barn, in root of pine tree; spike marked "U. S. B. M. 9576"	9,576.17
Swan City, 1.09 miles east of, on south side of road where creek and highway come together; rock marked "U. S. B. M. 9688"	9,687.28
Swan City, 2.05 miles east of, at Sneider's mining camp, 55 feet north of highway, 65 feet east of east margin of north cabin, in top of granite bowlder; aluminum tablet stamped "9823"	9,822.673
Swan City, 2.75 miles east of, 190 feet west of forks of road, north of road; point in square on rock marked "U. S. B. M. 9980"	9,979.47
Swan City, 3.75 miles east of, Farncombe Hill, 690 feet north of Boss mine mill, 60 feet west of log cabin; nail in root of pine tree; board nailed to tree marked "U. S. B. M. 10607"	10,606.81
Breckenridge, 4.78 miles east of, on top of Farncombe Hill, 20 feet east of road, 35 feet east of southeast end of Johnson's log cabin, in top of buried bowlder; aluminium tablet stamped "11069"	11,068.747
Breckenridge, 3.79 miles east of, upper end of Lincoln mining camp, 75 feet west of frame house with stone foundation, 15 feet south of highway at end of small log cabin, point on rock; telegraph pole marked "U. S. B. M. 10258"	10,257.84
Breckenridge, 2.41 miles east of, on road to Lincoln, 560 feet east of road running northeast, 15 feet south of road, in large granite bowlder; aluminum tablet stamped "9940"	9,940.069
Breckenridge, 1.2 miles east of, south of highway, 110 feet north of white frame house; point on rock marked "U. S. B. M. 9709"	9,708.52

Glenwood Springs, Leadville, Mount Jackson, and Snowmass Mountain 30′ quadrangles.

EAGLE, GARFIELD, LAKE, AND PITKIN COUNTIES.

The elevations in the following list were determined by primary leveling extended from bench marks at Glenwood Springs and Leadville, on the precise-level line from Denver.

The leveling was done in 1909 by F. J. McMaugh.

GLENWOOD SPRINGS QUADRANGLE.

Glenwood Springs southeast along Denver & Rio Grande R. R. to Cardiff.

	Feet.
Glenwood Springs, main entrance to Colorado Hotel, in face of stone column; aluminum tablet stamped "5764"	5,763.226
Glenwood Springs, at highway bridge; surface of water, May 22, 1909, at 8.50 a. m.	5,727.3
Glenwood Springs, 2.9 miles southeast of, 360 feet south of grain shed near road forks and about midway between railroad and upper road, in red sandstone bowlder; aluminum tablet stamped "5867 1909"	5,866.181

SNOWMASS MOUNTAIN QUADRANGLE.

Cardiff southeast along Denver & Rio Grande R. R. via Carbondale and Emma to point 1.8 miles east of junction of Denver & Rio Grande R. R. and Colorado Midland Ry.

	Feet.
Glenwood Springs, 6.1 miles southeast of, 1,650 feet southeast of milepost D–366, 10 feet west of track, on large red sandstone bowlder painted "5964 B. M."; chisel mark	5,963.28
Glenwood Springs, 6.7 miles southeast of, 525 feet west of railroad crossing, 15 feet north of track, 6 feet west of small cedar tree, in ledge; aluminum tablet stamped "5987 1909"	5,985.750
Carbondale, 2.4 miles northwest of, 50 feet west of public road, 50 feet east of track, in large bowlder; aluminum tablet stamped "6086 1909"	6,084.815
Carbondale, in front of railroad station, opposite telegraph window; top of north rail	6,171.1
Carbondale, at northwest corner, in north face of I. O. O. F. building; aluminum tablet stamped "6181 1909"	6,180.377
Carbondale, 3 miles east of, 90 feet north of railroad, east end of south abutment of highway bridge over Roaring Fork; aluminum tablet stamped "6278 1909"	6,276.845
Leon, 800 feet east of station, 65 feet southwest of switch stand, in small flat bowlder; aluminum tablet stamped "6430 1909"	6,429.418
Emma, in south face at southeast corner of Emma Mercantile Co.'s building; aluminum tablet stamped "6606 1909"	6,605.264
Junction of Denver & Rio Grande R. R. and Colorado Midland Ry., 0.6 mile east of, 340 feet west of milepost D–386, 50 feet north of track, in large bowlder; aluminum tablet stamped "6854 1909"	6,852.865
Junction of Denver & Rio Grande R. R. and Colorado Midland Ry., 1.8 miles east of, 490 feet east of milepost D–387, 50 feet east of road crossing, 10 feet north of track, on red sandstone bowlder marked "6895"; chisel mark	6,894.64

Junction of Denver & Rio Grande R. R. and Colorado Midland Ry. along Colorado Midland Ry. northwest to Basalt, thence 3.6 miles east.

Basalt, at northwest corner on west side of public school building, in stone foundation; aluminum tablet stamped "6625 1909"	6,624.070

MOUNT JACKSON QUADRANGLE.

Point 2.7 miles east of junction of Denver & Rio Grande R. R. and Colorado Midland Ry. southeast along former to Aspen, thence northwest along latter to Snowmass.

Junction of Denver & Rio Grande R. R. and Colorado Midland Ry., 4.6 miles east of, 540 feet west of milepost D 390, 25 feet north of track, in small granite bowlder; aluminum tablet stamped "7068 1909"	7,066.864
Woody Creek, at station, 120 feet northwest of road crossing, 90 feet north of water tank, in bowlder; aluminum tablet stamped "7275 1909"	7,274.709
Woody Creek, 1.8 miles east of, 7 feet east of track, on granite bowlder; chiseled square marked "7461"	7,460.54
Woody Creek, 2.4 miles southeast of, 30 feet southwest of track and about 1,000 feet west of Gray's ranch house, in large bowlder; aluminum tablet stamped "7516 1909"	7,514.769

	Feet.
Aspen, 2.5 miles northwest of, 50 feet west of milepost D 399, 15 feet south of track, in ledge; aluminum tablet stamped "7676 1909"	7,675.720
Aspen, 1.2 miles northwest of, 40 feet south of signpost "Station 1 mile," 20 feet west of track, on granite bowlder marked "7792"; chisel mark	7,791.41
Aspen, opposite Denver & Rio Grande R. R. station, east rail of main track; marked "7871"	7,870.6
Aspen, Pitkin County courthouse, in south face, at southwest corner; aluminum tablet stamped "7909 1909"	7,908.145
Aspen, opposite doorway under sign "Aspen" at station; top of north rail of north track	7,936.0
Aspen, 4.4 miles northwest of, Stapleton's ranch, 160 feet south of south end of siding, 10 feet east of track, on small bowlder, marked "7728"; chisel mark	7,727.43
Aspen, 5.5 miles northwest of, west side and 8 feet south of north end of trestle over dry gulch; top of bolt in guard rail, marked "7627"	7,626.61
Rathbone, in front of station; top of east rail	7,488.5
Watson's, at road crossing; top of north rail, marked "7148"	7,147.9
Watson's, 1.2 miles northwest of, 850 feet northwest of milepost 7, 20 feet north of track, on red sandstone bowlder, marked "7048 B. M."; chisel mark	7,047.51
Watson's, 3.7 miles northwest of, 10 feet south of track, on bowlder, marked "6913 B. M."; chisel mark	6,912.01
Snowmass, opposite center of platform; top of south rail, marked "6881"	6,880.9

Point 3.6 miles east of Basalt southeast along Colorado Midland Ry. to Busk tunnel.

Basalt, 3.6 miles east of, 240 feet east of milepost 182, 10 feet north of track, in ledge; aluminum tablet stamped "6901 1909"	6,900.295
Castles, opposite platform; top of north rail, marked "6959"	6,958.0
Castles, 1.8 miles east of, 60 feet west of milepost 179, 40 feet north of track, in ledge; aluminum tablet stamped "7027 1909"	7,026.238
Peachblow, opposite station signboard; top of south rail	7,099.1
Sloss, in west face at southwest corner of E. P. Sloss's house; aluminum tablet stamped "7180 1909"	7,179.980
Hopkins Spur, 0.2 mile east of, 200 feet west of milepost 174, 20 feet south of track, in large bowlder; aluminum tablet stamped "7350 1909"	7,349.034
Ruedi, 540 feet west of station, 85 feet north of main track, in south face of chimney of hotel; aluminum tablet stamped "7563 1909"	7,563.000
Ruedi, in front of station; top of north rail of main track, marked "7570"	7,569.5
Meredith, in front of station; top of north rail, marked "7777"	7,777
Meredith, 60 feet northwest of milepost 167, 45 feet north of track, about 100 feet south of old hotel building, in bowlder; aluminum tablet stamped "7773 1909"	7,772.596
Thomasville, 140 feet northeast of station, in bowlder; aluminum tablet stamped "7970 1909"	7,969.676

	Feet.
Muckawango, in front of station; top of north rail, marked "8242"	8,241.7
Norrie, 70 feet northeast of road crossing, 90 feet northwest of station platform, 40 feet southwest of post office, in bowlder; aluminum tablet stamped "8444 1909"	8,443.776
Norrie, in front of station platform; top of south rail, marked "8440"	8,439.4
Nast, 35 feet northwest of station, 20 feet north of track, in bowlder; aluminum tablet stamped "9060 1909"	9,059.483
Sellar, 970 feet north of station, 90 feet north of main track, 40 feet east of section house, in bowlder; aluminum tablet stamped "9609 1909"	9,609.112
Sellar, opposite station; south rail of main track, marked "9604"	9,603.4
Mallow, 90 feet southeast of, 20 feet south of side track, in large bowlder; aluminum tablet stamped "10170 1909"	10,170.000
Brockway, 0.4 mile east of, 470 feet east of milepost 147, 15 feet north of track, in bowlder; aluminum tablet stamped "10570 1909"	10,569.576
Ivanhoe, in front of station; top of south rail, marked "10936"	10,936.4
Ivanhoe, 220 feet southeast of station, 170 feet south of track, in large bowlder; aluminum tablet stamped "10930 1909"	10,929.719

LEADVILLE QUADRANGLE.

Busk east along Colorado Midland Ry. to Leadville.

Busk, in front of station; top of south rail	10,790
Busk, 170 feet southeast of railroad station, 150 feet south of track; point on large bowlder, marked "10791 B.M." (probably railroad bench mark)	10,790.20
Busk, 1.6 miles east of, 275 feet west of milepost 140, 10 feet south of track, in ledge; aluminum tablet stamped "10541 1909"	10,541.249
Arkansas Junction, 3.5 miles west of, 190 feet west of milepost 137, 7 feet south of track, in ledge; aluminum tablet stamped "10080 1909"	10,080.151
Arkansas Junction, 60 feet north of track, 720 feet north of station, 8 feet west of west fence of stock pen, in bowlder; aluminum tablet stamped "9697 1909"	9,696.869

Elkhead, Hahns Peak, Lay, Meeker, North Park, Pagoda, Rabbit Ears, and Rifle quadrangles.

GARFIELD, RIO BLANCO, AND ROUTT COUNTIES.

The elevations in the following list were determined by primary leveling extended from a precise level bench mark at Rifle. Orthometric corrections have been applied and adjustment made to accord with corrected primary level elevations in Wyoming.

The leveling was done in 1910 by C. H. Semper, except that in the northern portion of the Elkhead quadrangle, which was done by Donnell Miller in 1901 and by P. W. McMillan in 1910, and that in the North Park quadrangle, which was done by Donnell Miller in 1901.

RIFLE QUADRANGLE.

Rifle north along highway to point 5.6 miles south of Meeker.

	Feet.
Rifle, Denver & Rio Grande R. R. station, 35 feet north of west end, in top of concrete manhole at margin of highway; aluminum tablet stamped "5302"	5, 300. 876
Rifle, 2.2 miles north of, on west side of road, 300 feet south of ranch house; spike in telegraph pole, marked "5469"	5, 468. 109
Rifle, 3.2 miles north of, 60 feet south of J. C. Cook's ranch house yard fence corner, 15 feet east of road, in top of rock; aluminum tablet stamped "5544"	5, 542. 530
Rifle, 4.3 miles north of, on east side of road; spike in base of telephone pole, marked "5606"	5, 604. 956
Rifle, 5.3 miles north of, on east side of road; spike in second telephone pole south of wire fence, marked "5709"	5, 708. 336
Rifle, 6.3 miles north of, 0.3 miles north of Howard Coulter's house, on west side of road, in front face on pile of rock; aluminum tablet stamped "5812"	5, 811. 341
Rifle, 7.4 miles north of, fourth telephone pole south of milepost 8, on west side of road; spike in telephone pole, marked "5944"	5, 942. 588
Rifle, 8.3 miles north of, on east side of road; spike in first telephone pole south of milepost No. 9, marked "6035"	6, 033. 658
Rifle, 9.5 miles north of, 600 feet north of milepost 10, 5 feet west of road, 50 feet west of telephone pole, point of hill comes close to road in top of bowlder, 6 inches above ground; aluminum tablet stamped "6182"	6, 180. 941
Rifle, 10.6 miles north of, on west side of road, 50 feet south of creek crossing; spike in telephone pole, marked "6315"	6, 314. 329
Rifle, 11.4 miles north of, first telephone pole north of Reese's ranch house, on west side of road; spike in telephone pole, marked "6423"	6, 422. 313
Rifle, 11.9 miles north of, 1050 feet south of milepost 13, at top of rise and angle in road to west, 5 feet east of road, in top of large bowlder; aluminum tablet stamped "6531"	6, 529. 616
Rifle, 13.0 miles north of, at milepost 14; spike in telephone pole, marked "6658"	6, 657. 311
Rifle, 14 miles north of, 390 feet south of milepost 15, 20 feet south of bridge, on west side of road, top of bowlder; chiseled square marked "U. S. B. M. 6863"	6, 861. 571
Rifle, 15.3 miles north of, 475 feet north of milepost 16, on west margin of road, in top of 5 by 5 foot bowlder; aluminum tablet stamped "7050"	7, 048. 726
Rifle, 16.1 miles north of, north of milepost 17, 30 feet east of road, top of bowlder; chiseled square marked "U. S. B. M. 7333"	7, 332. 000
Rifle, 17 miles north of, spike in first telephone pole north of milepost 18, marked "U. S. B. M. 7440"	7, 438. 430
Rifle, 17.7 miles north of, spike in second telephone pole south of milepost 19, marked "7320"	7, 318. 840
Rifle, 18.7 miles north of, southeast corner of yard fence of J. A. Alley's ranch house (Rioblanco post office), in top of stone post; aluminum tablet stamped "7196"	7, 194. 920
Rioblanco (Alley's ranch), 0.9 mile north of; spike in first telephone pole south of milepost 21, marked "7244"	7, 242. 979

	Feet.
Rioblanco, 1.6 miles north of, 750 feet north of angle in road to west, 8 feet east of road, in top of large bowlder; aluminum tablet stamped "7265"	7,264.128
Rioblanco, 3.3 miles north of; spike in base of telephone pole, marked "7283"	7,281.551
Rioblanco, 4 miles north of, on west side of road; spike in second telephone pole north of milepost 20, marked "7193"	7,191.958
Rioblanco, 5 miles north of, in front of Engstrands ranch house, at gate leading to corral, in top of stone post; aluminum tablet stamped "7210"	7,209.060
Rioblanco, 6.4 miles north of, 2 posts set at culvert in road at foot of hill; spike in base of east post, marked "7156"	7,154.307
Rioblanco, 7 miles north of; spike in second telephone pole north of milepost 17, marked "7113"	7,112.156
Rioblanco, 7.8 miles north of, 270 feet northeast of milepost 16, 310 feet east of road, near summit of hill, top of rock; aluminum tablet stamped "7216"	7,214.602
Rioblanco, 9 miles north of, 1,500 feet north of milepost 15, west side of road; spike in telephone pole, marked "7213"	7,211.384
Rioblanco, 10.3 miles north of, directly opposite Balance Rock; spike in telephone pole, marked "7067"	7,065.995
Rioblanco, 10.5 miles north of, 50 feet south of milepost 13, 100 feet east of road, in top of bowlder; aluminum tablet stamped "7036"	7,035.043
Rioblanco, 11.7 miles north of, near top of small rise, at base of telephone pole, top of rock; chiseled square marked "U. S. B. M. 6942"	6,941.089
Rioblanco, 12.4 miles north of; spike in first telephone pole south of milepost 11, marked "6843"	6,841.729
Rioblanco, 13.3 miles north of, spike in second telephone pole south of milepost 10, marked "U. S. B. M. 6785"	6,784.052
Rioblanco, 14.3 miles north of, 180 feet north of milepost 9, 100 feet northeast of Grove's ranch house, 12 feet east of road, in top of bowlder; aluminum tablet stamped "6699"	6,697.623
Rioblanco, 15.5 miles north of, east side of road, in big flat; spike in telephone pole, marked "U. S. B. M. 6540"	6,538.347
Rioblanco, 16.5 miles north of, near eleventh telephone pole north of milepost 7, 150 feet east of road, in west face of one of three bowlders, 55 feet long by 20 feet high; aluminum tablet stamped "6488"	6,486,901
Meeker, 5.6 miles south of, 200 feet north of milepost 6, 15 feet east of road, top of rock; chiseled square marked "U. S. B. M. 6395"	6,394.060

MEEKER QUADRANGLE.

Point 5.6 miles south of Meeker along highway via Axial to Craig.

Meeker, 4.6 miles south of, opposite milepost 5; spike in telephone pole, marked "U. S. B. M. 6259"	6,257.471
Meeker, 3.6 miles south of, east side of road; spike in second telephone pole north of milepost 4, marked "U. S. B. M. 6142"	6,140.599
Meeker, 3.3 miles south of; floor of south end of bridge over White River	6,127.7
Meeker, 3.2 miles west of, at east gate to cross L (Ⱡ) ranch, owned by U. S. Montgomery, 4 feet north of north gate post, in top of stone post; aluminum tablet stamped "6150"	6,149.220

	Feet.
Meeker, 1.8 miles west of, 60 feet east of milepost 2, south margin of road on rock; chiseled square marked "U. S. B. M. 6221"	6,219.807
Meeker, 1 mile west of, at forks of road, at base of telephone pole; chiseled square, top of rock marked "U. S. B. M. 6247"	6,245.972
Meeker, front face of Meeker Hotel; aluminum tablet stamped "6240"	6,238.943
Meeker, 2.4 miles north of; spike in telephone pole 15 feet east of road, marked "U. S. B. M. 6466"	6,464.288
Meeker, 3.1 miles north of, at top of small rise, west margin of road, at wire fence, in top of stone post; aluminum tablet stamped "6578"	6,576.562
Meeker, 4.1 miles north of, on east side of road; spike in telephone pole, marked "U. S. B. M. 6781"	6,779.999
Meeker, 5.6 miles north of, at lane leading into W. H. Miller's ranch house, north angle, east side, in top of rock; aluminum tablet stamped "6777"	6,776.190
Meeker, 6.8 miles north of, east side of road; spike in second telephone pole north of small reservoir, marked "U. S. B. M. 6900"	6,898.292
Meeker, 7.8 miles north of, at base of third telephone pole north of milepost 8; painted square on rock marked "U. S. B. M. 6985"	6,983.184
Meeker, 8.5 miles north of, at southeast corner of ranch-house yard of Harp & Moulton, in top of stone post; aluminum tablet stamped "7051"	7,049.816
Meeker, 9.8 miles north of, on south slope of Ninemile Hill, 50 feet south of culvert west margin of road, top of rock; chiseled square marked "U. S. B. M. 7279"	7,277.964
Meeker, 10.3 miles north of, on summit of Ninemile Hill, 15 feet east of old road and between roads, top of stone post; chiseled square marked "U. S. B. M. 7496"	7,494.204
Meeker, 11.5 miles north of, 1.2 miles north of Ninemile Hill, at top of small rise, 10 feet east of road, in top of stone post; aluminum tablet stamped "7403"	7,401.899
Meeker, 12.4 miles north of, 8 feet west of road, top of rock; chiseled square marked "U. S. B. M. 7219"	7,218.024
Meeker, 13.5 miles north of, at gate leading into J. Freund's ranch house, top of rock; chiseled square marked "U. S. B. M. 7108"	7,106.944
Meeker, 14.6 miles north of, 1 mile north of J. Freund's ranch, at bridge across creek, 30 feet west of bridge, 25 feet south of wire fence, top of stone post; aluminum tablet stamped "6910"	6,908.319
Meeker, 15.8 miles north of, spike in telephone pole on west side of road, marked "U. S. B. M. 6805"	6,803.436
Meeker, 16.6 miles north of, 0.3 mile north of James's ranch; spike in telephone pole, marked "U. S. B. M. 6740"	6,738.714
Axial, 3.4 miles south of, 1.6 miles south of Joe Collums's, directly oposite small log cabin, in meadow, at fence line, in top of stone post; aluminum tablet stamped "6661"	6,659.560
Axial, 2.5 miles south of, 0.7 mile south of Joe Collums's, south of sharp angle in road, on west margin at fence line, top of large rock; chiseled square marked "U. S. B. M. 6616"	6,614.676
Axial, 1.8 miles south of, directly opposite Joe Collums's ranch house, in highway, top of stone post; aluminum tablet stamped "6587"	6,585.887
Axial, at northwest corner of J. W. Huguss's old store, top of stone post; aluminum tablet stamped "6460"	6,458.741

	Feet.
Axial, 1 mile north of, at forks of road, at top of hill; spike in telephone pole, marked "U. S. B. M. 6500"	6,498.872
Axial, 2 miles east of, on east slope of hill; spike in telephone pole, marked "U. S. B. M. 6499"	6,497.147
Axial, 3.8 miles east of, 160 feet east of bridge over Milk Creek, 10 feet north of road, in top of stone post; aluminum tablet stamped "6241"	6,239.162
Axial, 5 miles east of, on east slope of hill; spike in telephone pole marked "U. S. B. M. 6285"	6,283.333
Axial, 5.8 miles east of, 0.6 mile west of Iles's ranch house, on north side of road; spike in telephone pole marked "U. S. B. M. 6258"	6,256.728
Axial, 6.4 miles east of, at gate leading into T. H. Iles's ranch, at fence, top of stone post; bronze tablet stamped "6272"	6,270.374
Axial, 7.4 miles east of; spike in telephone pole 12 feet inside of fence, marked "U. S. B. M. 6294"	6,293.040
Axial, 8 miles east of, on west slope of hill; spike in telephone pole marked "U. S. B. M. 6370"	6,368.344
Axial, 9 miles east of, 2.7 miles east of Iles's ranch, at top and south side of small rise, in top of stone post; aluminum tablet stamped "6525"	6,523.716
Axial, 10.2 miles east of, 0.5 mile west of stage station, at division wire fence, top of stone post; chiseled square marked "U. S. B. M. 6509"	6,508.042
Axial, 11 miles east of, at angle in road to north, in north corner fence post; spike marked "U. S. B. M. 6494"	6,492.838
Axial, 11.5 miles east of, at top of summit, north side of road, top of stone post; chiseled square marked "U. S. B. M. 6622"	6,620.122
Axial, 12 miles east of, 2.3 miles south of Williams Fork, at top of summit, 12 feet east of road, top of stone post; aluminum tablet stamped "6712"	6,710.774
Axial, 13.2 miles east of, 1.2 miles south of Williams Fork, on west margin of road, top of rock; chiseled square marked "U. S. B. M. 6466"	6,464.827
Williams Fork (Hamilton's ranch), south side of river, 10 feet east of abutment; iron post stamped "6238" (supposed to be Reclamation Service bench mark)	6,235.325
Axial, 16.8 miles east of, in canyon on west margin of road, top of rock; chiseled square marked "U. S. B. M. 6255"	6,253.464
Axial, 17.8 miles east of, 200 feet north of alfalfa field, on north margin of road, top of large bowlder; chiseled square marked "U. S. B. M. 6223"	6,221.529
Axial, 18.2 miles east of, at gate leading into George Pitchford's ranch house, 10 feet east of gate, 10 feet north of wire fence, in top of large bowlder; aluminum tablet stamped "6225"	6,223.031
Axial, 19.3 miles east of, on west margin of road, 20 feet north of wire fence corner, top of rock; chiseled square marked "U. S. B. M. 6178"	6,176,691
Axial, 21.1 miles east of, at top of hill, 0.5 mile east of Williams Fork Creek at angle in wire fence, top of stone post; aluminum tablet stamped "6449"	6,447.138
Axial, 22.5 miles east of; spike in telephone pole where line crosses road, marked "U. S. B. M. 6383"	6,381.450
Axial, 23.7 miles northeast of, 100 feet north of bridge, on west side of road; spike in telephone pole, marked "6276"	6,274.637

	Feet.
Craig, 5.1 miles south of, at gate leading into Big Bottom ranch, at fence line, top of stone post; aluminum tablet stamped "6206"	6, 204. 572
Craig, 4.4 miles south of, 125 feet east of road; spike in telephone pole, marked "U. S. B. M. 6311"	6, 309. 197
Craig, 2.8 miles south of, about 1,000 feet south of summit, east side of road in top of stone post; aluminum tablet stamped "6422"	6, 420. 898
Craig, 1.6 miles south of, at forks of road up hill, on east side, at gate; spike in telephone pole, marked "U. S. B. M. 6190"	6, 188. 481
Craig, 1.4 miles south of Bear River, under bridge; surface of water, September 30, 1910	6, 175. 9

LAY QUADRANGLE.

Craig along highway east 2.8 miles.

Craig, front face town hall; aluminum tablet stamped "6191"	6, 191. 996
Craig, 0.9 mile east of, at angle in road to southeast; spike in telephone pole, marked "U. S. B. M. 6201"	6, 202. 252
Craig, 2.1 miles east of, at summit of small rise, south side of road; spike in telephone pole, marked "U. S. B. M. 6319"	6, 317. 218
Craig, 2.8 miles east of, at summit of hill, on south side of road, top of stone post; aluminum tablet stamped "6377"	6, 375. 886

ELKHEAD QUADRANGLE.

Point 2.8 miles east of Craig along highway east to point 4 miles west of Bear River.

Craig, 4.2 miles east of, 350 feet east of small log cabin, on south side of road; spike in telephone pole, marked "U. S. B. M. 6244"	6, 242. 825
Craig, 6.6 miles east of, iron bridge over Elkhead Creek, west abutment, south side wing wall, top of; aluminum tablet stamped "6239"	6, 237. 709
Craig, 7.4 miles east of, 0.8 mile east of Elkhead Creek, on south side of road; chiseled square top of bowlder, marked "U. S. B. M. 6244"	6, 242. 887
Craig, 8.6 miles east of, 2 miles east of Elkhead Creek, south side of road at corner of wire fence; spike in telephone pole, marked "U. S. B. M. 6314"	6, 312. 738
Craig, 9.5 miles east of, 2.9 miles east of Elkhead Creek, at gate leading into lower Cary ranch, 6 feet east of, top of stone post; aluminum tablet stamped "6314"	6, 312. 084
Craig, 10.4 miles east of, 3.8 miles east of Elkhead Creek, where road turns up horseshoe bend, on north side of road; spike in telephone pole, marked "U. S. B. M. 6279"	6, 277. 068

Smith's ranch northwest along highway to Honnold, on Wyoming line.

Palmer's ranch, 600 feet northeast of house, south end of rocky ridge, east edge of road; set in large granite bowlder; aluminum tablet stamped "7722"	7, 723. 573
Gardner's ranch, 150 feet south of house, north edge of road; iron post stamped "7024"	7, 025. 473
Hancock's ranch, 0.2 mile southwest of house, in river bottom, 400 feet south of river, 200 feet north of road, in rock 6 by 4 and 2 feet high; aluminum tablet stamped "6953"	6, 954. 458

NOTE.—The following bench marks were established by a spur line run by Donnell Miller in 1901 from the Encampment special (Wyo.) quadrangle.

Salisbury's ranch along wagon road up Snake River via Honnold post office to Slater Park.

	Feet.
Honnold, at front gate to post office, 5 miles east of Salisbury's ranch, NW. ¼ of sec. 15, T. 12 N., R. 87 W., in sandstone; bronze tablet stamped "6851 LARAMIE"	6, 852. 116
Honnold, 4.1 miles south of, stone 50 feet east of south corner of Fleming's cabin, sec. 33, T. 12 N., R. 87 W., 200 feet east of road; bronze tablet stamped "7008 LARAMIE"	7, 009. 089
Honnold, 6.6 miles south of, stone set in ground 50 feet west of road at crossing of Willow Creek, at point where roads fork to Slater post office and Slater Park; bronze tablet stamped "7191 LARAMIE"	7, 192. 411
Honnold, 9.8 miles south of, 40 feet east of road, about 1 mile north of divide at Columbus Mountain, in stone; bronze tablet stamped "8306 LARAMIE"	8, 307. 369

NOTE.—The following bench marks were established from leveling in the Medicine Bow (Wyo.) quadrangle by Donnell Miller in 1901.

NORTH PARK QUADRANGLE.

Point 3.6 miles southwest of Mountain Home southwest to Pinkhampton, thence northwest to Colorado-Wyoming State line.

Mountain Home, 3.6 miles southwest of, 50 feet east of road, 10 feet south of fence corner at ranch, between telephone poles 1576–1577; iron post stamped "8611 LARAMIE"	8, 612. 123
Mountain Home, 6.5 miles southwest of, 50 feet east of road, 10 feet west of telephone pole 1683, 500 yards east of ranch house; iron post stamped "8437 LARAMIE"	8, 438. 141
Pinkhampton, 30 feet north of post office, 7 feet north of road; iron post stamped "8033 LARAMIE"	8, 034. 110
Pinkhampton, 4 miles northwest of, 50 feet east of Platte River, 200 feet north of ford across same, 10 feet east of road, iron post stamped "7831 LARAMIE"	7, 831. 956
Pinkhampton, 6.5 miles northwest of, top of small divide, 30 feet north of road; iron post stamped "7952 LARAMIE"	7, 953. 104
Pinkhampton, 9 miles northwest of, 20 feet north of county road, between telephone poles 3097–3098; iron post stamped "7990 LARAMIE"	7, 990. 986

PAGODA QUADRANGLE.

Point 4 miles west of Bear River east along highway to Pool.

Elkhead Creek, 4.7 miles east of, at summit of hill, north side of road; spike in telephone pole, marked U. S. B. M. 6440"	6, 438. 778
Elkhead Creek, 5.7 miles east of, at upper Cary ranch, at east corner of fence, at iron gate leading into ranch, top of stone post; aluminum tablet stamped "6325"	6, 323. 222

	Feet.
Elkhead Creek, 7.3 miles east of, at forks of road to Hayden, 200 feet south of fork; spike in telephone pole, marked "U. S. B. M. 6392"	6,390.869
Bear River, bridge over, top of north abutment west wing wall; aluminum tablet stamped "6308"	6,306.109
Bear River; surface of water under bridge, October 8, 1910	6,294.3
Bear River, 1.1 miles east of, at west corner of wire fence around green house; spike in telephone pole, marked "U. S. B. M. 6232"	6,230.090
Hayden, 1.3 miles west of, on north side of road; spike in telephone pole, marked "U. S. B. M. 6334"	6,332.829
Hayden, southeast corner foundation of town pump; aluminum tablet stamped "6351"	6,349.262
Hayden, 1 mile east of, north side of road; spike in telephone pole, marked "U. S. B. M. 6370"	6,368.597
Hayden, 2.3 miles east of, in front of Mrs. A. S. Williams house, north side of road; spike in telephone pole, marked "U. S. B. M. 6395"	6,393.372
Hayden, 3 miles east of, at road to north, northwest corner of fence, in top of stone post; aluminum tablet stamped "6406"	6,404.073
Hayden, 4.3 miles east of, north side of road; spike in telephone pole, marked "U. S. B. M. 6407"	6,405.939
Hayden, 4.8 miles east of, at forks of road leading to river bridge, north side of road; spike in telephone pole, marked "U. S. B. M. 6418"	6,416.764
Hayden, 5.7 miles east of, north end of bridge over Bear River, 40 feet east of river, 30 feet east of road, in top of stone post; aluminum tablet stamped "6406"	6,404.972
Hayden, 8.1 miles east of, in canyon, on east margin of road, top of rock; chiseled square marked "U. S. B. M. 6462"	6,460.547
Hayden, 8.9 miles east of, 650 feet northwest of small wooden road bridge, at sharp curve in road, 15 feet north of road, in top of stone post; aluminum tablet stamped "6491"	6,489.868
Hayden, 10 miles east of, 600 feet east of old log cabin on north margin of road, top of bowlder; chiseled square marked "U. S. B. M. 6448"	6,446.187
Hayden, 10.6 miles east of, at corner of wire fence, on south side of road, top of bowlder; chiseled square marked "U. S. B. M. 6448"	6,446.895
Hayden, 11.6 miles east of, on south margin of road; spike in telephone pole, marked "U. S. B. M. 6534"	6,532.744
Hayden, 12.5 miles east of, directly opposite Wilbur Rule's ranch house, at south margin of road, in top of large bowlder; aluminum tablet stamped "6467"	6,465.063
Hayden, 13.6 miles east of, 230 feet east of George Marshall's house, south margin of road, top of bowlder; chiseled square marked "U. S. B. M. 6473"	6,471.892
Hayden, 14.5 miles east of, south side of road, 600 feet west of ranch house; spike in telephone pole, marked "U. S. B. M. 6511"	6,509.554
Pool, southwest corner of yard in front of Pool post office, in top of stone post; aluminum tablet stamped "6643"	6,641.535
Pool, 0.9 mile east of, at top of hill, south side of road; spike in telephone pole, marked "U. S. B. M. 6628"	6,626.811

RABBIT EARS QUADRANGLE.

Pool east along highway to Steamboat Springs.

	Feet.
Pool, 2.2 miles east of, south margin of road; spike in telephone pole, marked "U. S. B. M. 6561"	6, 559. 862
Steamboat Springs, 1 mile west of, at forks of road to Hayden and Hahns Peak, in fork, top of stone post; aluminum tablet stamped "6676"	6, 674. 055
[NOTE.—A double line was run from this bench mark to Steamboat Springs, the closure error being +0.001 foot.]	
Steamboat Springs, spring house, 200 feet northwest of Cabin Hotel, top of concrete post of railing; aluminum tablet stamped "6701"	6, 699. 210
Steamboat Springs, southwest corner of road bridge over Bear River; spike in stringer (Denver, Northwestern & Pacific Ry. bench mark, railway elevation 6,679.80 feet)	6, 690. 538
Steamboat Springs, in front of station; top of rail	6, 693. 5
Steamboat Springs, 0.5 mile east of, 125 feet south of track; spike in root of cottonwood tree in clump of trees (Denver, Northwestern & Pacific Ry. bench mark, railway elevation 6,687.46 feet)	6, 698. 462

HAHNS PEAK QUADRANGLE.

Pool east along highway to Steamboat Springs.

Pool, 3 miles east of, 40 feet west of gate leading to F. Coleman's ranch house, south side of road, top of stone post; aluminum tablet stamped "6600"	6, 597. 862
Steamboat Springs, 6.6 miles west of, bridge over Elk River, west abutment, south end, at top; aluminum tablet stamped "6593" (set by other parties)	6, 591. 004
Surface of water under bridge, October 19, 1910	6, 580
Steamboat Springs, 5.5 miles west of, at west corner of wire fence, gate leading to ranch house; spike in corner post marked "U. S. B. M. 6712"	6, 710. 727
Steamboat Springs, 4.7 miles west of, summit of divide between Bear and Elk rivers, south side of road, at fence, top of stone post; aluminum tablet stamped "6872"	6, 870. 168
Steamboat Springs, 3.7 miles west of, north side of road; spike in telephone pole marked "U. S. B. M. 6716"	6, 714. 479
Steamboat Springs, 1.8 miles west of, north side of road, at fork in road to Hahns Peak; spike in telephone pole marked "U. S. B. M. 6714"	6, 711. 988

Steamboat Springs north along highway to point 5.3 miles north of Columbine.

Steamboat Springs, 2.1 miles north of, on east side of road; spike in telephone pole, marked "U. S. B. M. 6739"	6, 737. 813
Steamboat Springs, 4.1 miles north of, on summit of divide between Elk River and Bear River, 18 feet west of road; iron post stamped "6903"	6, 901. 377
Steamboat Springs, 4.9 miles north of, at forks of road, 60 feet north of fork on west side of road; spike in telephone pole marked "U. S. B. M. 6738"	6, 736. 256

	Feet.
Steamboat Springs, 6.5 miles north of, at bridge over Mad Creek, 90 feet south of bridge, 15 feet east of road; iron post stamped "6747"	6,745.920
Steamboat Springs, 7.5 miles north of, west side of road, in canyon; top of granite rock marked "U. S. B. M. 6766"	6,764.042
Steamboat Springs, 9.7 miles north of, in front of C. E. Hempstreet's ranch house, 25 feet south of south side of house, 20 feet east of road; iron post stamped "6898"	6,896.255
Steamboat Springs, 12.7 miles north of, opposite Moon Hill schoolhouse, at northeast corner of yard fence around V. C. Adams's ranch house; iron post stamped "7000"	6,998.771
Steamboat Springs, 14 miles north of; floor of bridge over Elk River.	7,015.6
Steamboat Springs, 14 miles north of, under bridge; Elk River, surface of water, October 29, 1910	7,004.4
Steamboat Springs, 15.5 miles north of, at Franz's ranch, 210 feet north of north side of house, 20 feet west of road; iron post stamped "7118"	7,116.082
Steamboat Springs, 18.1 miles north of, at Ducey's ranch house, 60 feet north of north side of house, at west road fence line, at fork of road to northeast; iron post stamped "7274"	7,272.358
Steamboat Springs, 21.3 miles north of, in canyon, 400 feet northeast of Mike Condlin's ranch house, at west margin of road, in top of stone post; aluminum tablet stamped "7893"	7,891.373
Hahns Peak, 3.3 miles south of, under bridge over Willow Creek; surface of water, October 31, 1910	7,875.2
Hahns Peak, southeast corner of county courthouse, near sidewalk; iron post stamped "8153"	8,151.084
Hahns Peak, 2.7 miles north of, 150 feet north of Cap Smith's cabin, 10 feet west of road; iron post stamped "8389"	8,387.336
Columbine, 300 feet west of Carson's store, 35 feet south of road, in edge of timber; iron post stamped "8699"	8,697.627
Columbine, 2.3 miles north of, 110 feet north of north end of cut-off road, 15 feet north of main road, on side hill, in top of bowlder outcrop; aluminum tablet stamped "8272"	8,269.750
Columbine, 5.3 miles north of, at top of small rise north of gully, 0.7 mile north of Smith's ranch, 5 feet east of road, in granite bowlder outcrop; aluminum tablet stamped "7870"	7,871.723

De Beque special quadrangle.

MESA COUNTY.

The elevations in the following list are based on unchecked spur lines based on the precise level line at De Beque.

The leveling was done by F. H. Nelson in 1910.

DE BEQUE SPECIAL QUADRANGLE.

De Beque northwest up Roan Creek valley to point near junction of Roan Creek and Clear Creek (single spur line).

	Feet.
De Beque, Denver & Rio Grande R. R. water tower, 150 west of station, west of Main Street, northwest pier of water tank, in pedestal; aluminum tablet stamped "4937"	4,935.904

	Feet.
De Beque, 3 miles northwest of, junction of Roan Creek and Dry Fork, on main road north, 120 feet south of Placer Corner section; top of rock	5,075.29
De Beque, 7 miles northwest of, at schoolhouse, on main road north up Roan Creek, southwest corner foundation of school; chisel mark	5,264.79
De Beque, 12 miles northwest of, junction of roads, at junction of Roan Creek and Clear Creek, 1,000 feet east of large rock; aluminum tablet stamped "5593"	5,590.782

Junction of Roan Creek and Kimball Creek roads west 3 miles along Kimball Creek road (single spur line).

De Beque, 11 miles northwest of, on southeast pier of bridge over Roan Creek; chisel mark	5,386.02
De Beque, 13 miles northwest of, 350 feet northwest of house, on rock on wash north of Kimball Creek road; aluminum tablet stamped "5841"	5,829.138
Tps. 7 and 8 S., Rs. 97 and 98 W., 250 feet southwest of corner of, just west of bridge over Roan Creek, in ledge; aluminum tablet stamped "5185"	5,183.207

Grand Junction quadrangle.

MESA COUNTY.

The elevations in the following list were determined by a double line of primary leveling, and constitute the Colorado portion of the results of a line extended from Salt Lake, Utah, along the Denver & Rio Grande Railroad to Grand Junction, Colo. Corrections have been applied as in precise leveling, including orthometric corrections and adjustment of closure error of about 1 foot. The elevations adopted at Salt Lake and Grand Junction were determined in accordance with a preliminary adjustment by the Coast and Geodetic Survey in 1911.

The leveling was done in 1910 by L. F. Biggs.

GRAND JUNCTION QUADRANGLE.

Utaline northeast to Mack, thence southeast to Grand Junction along the Denver & Rio Grande R. R.

	Feet.
Milepost 295, in base of; spike with aluminum tag stamped "4345"	4,346.378
Milepost 296, in base of; spike with aluminum tag stamped "4358"	4,359.233
Milepost 297, in base of; spike with aluminum tag stamped "4358"	4,360.611
Milepost 298, in base of; spike with aluminum tag stamped "4378"	4,380.606
Milepost 299, in base of; spike with aluminum tag stamped "4377"	4,379.497
Shale, 0.2 mile west of milepost 300, 30 feet north of track, in red sandstone ledge; aluminum tablet stamped "4390, 73"	4,391.798
Milepost 300, in base of; spike with aluminum tag stamped "4393"	4,395.01
Milepost 301, in base of; spike with aluminum tag stamped "4401"	4,402.838
Milepost 302, in base of; spike with aluminum tag stamped "4394"	4,395.314
Milepost 303, in base of; spike with aluminum tag stamped "4391"	4,392.170

	Feet.
Milepost 304, in base of; spike with aluminum tag stamped "4411"	4,412.899
Ruby, 200 feet north of station, 25 feet west of track, opposite small building, in bowlder; aluminum tablet stamped "4415, 74"	4,416.776
Milepost 305, in base of; spike with aluminum tag stamped "4410"	4,411.815
Milepost 306, in base of; spike with aluminum tag stamped "4422"	4,423.731
Milepost 307, in base of; spike with aluminum tag stamped "4442"	4,445.719
Milepost 308, in base of; spike with aluminum tag stamped "4480"	4,483.197
Mack, 300 feet east of station, in fence corner at road crossing; iron post stamped "4531, 75"	4,532.488
Mack, 250 feet southwest of station, west edge of right of way; concrete pier (U. S. Reclamation Service bench mark)	4,529.012
Milepost 310, in base of; spike with aluminum tag stamped "4565"	4,568.592
Milepost 311, in base of; spike with aluminum tag stamped "4560"	4,563.342
Milepost 312, in base of; spike with aluminum tag stamped "4520"	4,522.558
Loma, 340 feet south of station, opposite blacksmith shop, south edge of right of way, in fence corner; iron post stamped "4510"	4,511.776
Milepost 313, in base of; spike with aluminum tag stamped "4497"	4,498.28
Milepost 314, in base of; spike with aluminum tag stamped "4471"	4,472.92
Milepost 315, in base of; spike with aluminum tag stamped "4463"	4,474.47
Milepost 316, in base of; spike with aluminum tag stamped "4482"	4,483.746
Fruita, 0.5 mile west of, north end of east abutment of bridge 361B; aluminum tablet stamped "4486, 77"	4,487.493
Milepost 317, in base of; spike with aluminum tag stamped "4489"	4,491.097
Milepost 318, in base of; spike with aluminum tag stamped "4505"	4,506.992
Milepost 319, in base of; spike with aluminum tag stamped "4518"	4,519.523
Milepost 320, in base of; spike with aluminum tag stamped "4516"	4,517.716
Rohne, 0.2 mile west of, 300 feet west of road crossing, opposite brick schoolhouse, in south end of concrete culvert; aluminum tablet stamped "4517, 78"	4,518.565
Milepost 321, in base of; spike with aluminum tag stamped "4519"	4,520.341
Milepost 322, in base of; spike with aluminum tag stamped "4514"	4,515.667
Milepost 323, in base of; spike with aluminum tag stamped "4520"	4,521.373
Grand Junction, 4.6 miles west of, south edge of railroad right of way, opposite Columbine schoolhouse; iron post stamped "4526, 79"	4,528.148
Milepost 324, in base of; spike with aluminum tag stamped "4528"	4,529.595
Milepost 325, in base of; spike with aluminum tag stamped "4535"	4,536.823
Milepost 326, in base of; spike with aluminum tag stamped "4543"	4,545.335
Milepost 327, in base of; spike with aluminum tag stamped "4547"	4,548.509

Lake City and Ouray 15′ quadrangles; Montrose and Uncompahgre Peak 30′ quadrangles.

GUNNISON, HINSDALE, MONTROSE, AND OURAY COUNTIES.

The elevations in the following list were determined by primary leveling extended from Ridgway and Montrose on the precise level line run from near Denver in 1908, and accord with the 1911 preliminary adjustment of precise leveling.

The leveling was done in the Ouray 15′ (Montrose 30′) quadrangle in 1901 by Chester Irvine in the Lake City 15′ (Uncompahgre Peak 30′) quadrangle in 1903 by J. E. Chapson; in the Montrose and

Uncompahgre Peak 30′ quadrangles n 1908 by R. P. Thompson; and in the Montrose quadrangle in 1909 by J. A. Burris and F. J. McMaugh.

The bench marks set in 1908 were not stamped with the figures of elevation.

OURAY 15′ (MONTROSE 30′) QUADRANGLE.

Ouray along Ouray and Silverton stage road to old tollgate.

	Feet.
Ouray, in front of Denver & Rio Grande R. R. station; top of rail (railroad company's elevation 7,706)	7,706.6
Ouray, 16 feet southeast of Denver & Rio Grande R. R. station, at corner of platform near telegraph pole; iron post stamped "7712 OURAY"	7,708.517
Ouray, in southwest corner of Miners & Merchants Bank, under Beaumont Hotel, 18 inches above sidewalk; bronze tablet stamped "7806 OURAY"	7,802.728
Ouray, 2.8 miles southeast of, 150 feet west of tollgate, on south side of road, in granite bowlder; bronze tablet stamped "8557 OURAY"	8,553.726

Ouray north along Denver & Rio Grande R. R. to Bachelor Switch, thence north along wagon road to Ridgway.

Bachelor switch, 85 feet northwest of north end of siding, 35 feet west of main track, northwest of railroad crossing and west side of wagon road; iron post stamped "7586 OURAY"	7,582.539
Portland, 0.5 mile north of, 5.6 miles southeast of Ridgway, on east side of road at bend, near gate to Jackson's ranch; iron post stamped "7237 OURAY"	7,233.592
Ridgway, 3.5 miles southeast of, 17 feet northeast of gate to Stanton's ranch, west of road; iron post stamped "7181 OURAY"	7,177.259

Ridgeway east up Cow Creek and Owl Creek to pass of West Fork of Cimarron Creek.[1]

Ridgway, 2.7 miles northwest of, 120 feet west of bridge over Dry Creek, southwest of crossroads and northeast of Swanson's ranch, on line between secs. 3 and 10; iron post stamped "7024 OURAY"	7,020.217
Ridgway, 5.7 miles northeast of, 0.4 mile west and 0.1 mile south of northeast corner of, T. 45 N., R. 8 W., 25 feet west of road near gate to Couchman's ranch; iron post stamped "7326 Ouray"	7,322.433
Ridgway, 9.1 miles northeast of, at end of Upper Cow Creek county road, near gate to Critchfield's ranch; iron post stamped "7604 OURAY"	7,599.876
Ridgway, 11.2 miles east of, south side of Owl Creek, 20 feet south of wagon road and west of salt lick, in bowlder; bronze tablet stamped "8163 OURAY"	8,158.460

American Flat east to North Fork of Henson Creek.[1]

Ouray, 12.8 miles east of, at timber line 2 miles east of lake, at east end of American Flat, 45 feet southwest of Bent's cabin, at east end of mine road, in bowlder; bronze tablet stamped "11687 OURAY"	11,683.431

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[1] An excessive error was distributed in this line.

Jacksonville along trail west and south up West Fork to point near Courthouse Mountain.

	Feet.
Jacksonville, 1.5 miles northwest of, on divide between forks of Cimarron Creek, 15 feet south of trail, in low granite bowlder; bronze tablet stamped "8979 OURAY"	8, 974. 407
Jacksonville, 5.5 miles southwest of, west side of West Fork, in forks of trail, in 4 by 4 foot bowlder; bronze tablet stamped "9707 OURAY"	9, 702. 487
Pass between West Fork of Cimarron and Cow creeks, north of Courthouse Mountain, 20 feet west of trail and 200 feet north of irrigating ditch, in granite bowlder; bronze tablet stamped "10120 OURAY"	10, 116. 145

MONTROSE QUADRANGLE.

Ridgway west along Rio Grande Southern R. R. to Sams.[1]

Ridgway, 3.1 miles west of, 30 feet north of railroad, 400 feet west of third milepost out from Ridgway, in green bowlder; aluminum tablet	7, 181. 703
Ridgway, 6 miles west of, 20 feet south of railroad, 250 feet east of sixth milepost, in limestone 8 by 10 feet; aluminum tablet	7, 525. 394
Ridgway, 9 miles west of, 60 feet east of highway, 50 feet west of a 24-inch pine tree, in one of a pile of rocks; aluminum tablet	7, 864. 958
Ridgway, 12.0 miles west of, 20 feet west of railroad, 150 feet north of twelfth milepost, in white sandstone 18 by 18 inches, 800 feet north of highway crossing; aluminum tablet	8, 734. 995
Dallas Divide, in front of section house; top of rail	8, 969. 6
Ridgway, 15 miles west of, 100 feet east of fifteenth milepost, 60 feet north of railroad, in sandstone 8 by 8 feet; aluminum tablet	8, 756. 840
Dallas, 4.0 miles west of, 800 feet west of switch below sawmill, on 3 by 6 foot sandstone; chiseled circle	8, 445. 93

Montrose southwest along highway to Sams.

Montrose, 3.2 miles southwest of, 150 feet east of intersection of Grandview and Oakgrove avenues, 70 feet northeast of corner of fence, in ledge; aluminum tablet stamped "5948 1909"	5, 947. 893
Montrose, 4.8 miles southwest of, southeast corner of bridge over canal; top of painted bolt marked "6019 B. M."	6, 018. 53
Montrose, 5.6 miles southwest of, 600 feet southwest of George Christensen's house, 60 feet west of road, 2 feet east of wire fence, in ledge; aluminum tablet stamped "6089 1909"	6, 088. 924
Montrose, 7.9 miles southwest of, 200 feet northeast of "Seven-mile tree," 30 feet west of road, on ledge; chisel mark, with paint mark "6519 B. M."	6, 519. 21
Montrose, 8.7 miles southwest of, 15 feet west of road, in ledge; aluminum tablet stamped "6733 1909"	6, 732. 531
Montrose, 11.8 miles southwest of, 20 feet east of road, in ledge; aluminum tablet stamped "7387 1909"	7, 386. 579
Brown's Spring, about 160 feet east of road, in ledge; aluminum tablet stamped "8408 1909"	8, 408. 182

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[1] An error of 1 foot was distributed in this line.

	Feet.
Brown's Spring, 2.8 miles south of, 50 feet east of road, 20 feet north of triple pine tree, in 6 by 8 by 30 inch stone; aluminum tablet stamped "9159 1909"	9,159.390
Finch's ranch, 120 feet northwest of house, 3 feet east of fence, 3 feet south of granary, in top of stone 6 by 10 by 24 inches, in ground; aluminum tablet stamped "8568 1909"	8,568.173
Finch's ranch, 3.6 miles south of, west side of road, at angle in road to east; iron post stamped "8950 1909"	8,949.757
Dallas Divide, 9.8 miles west of, 20 feet northeast of house, in stone in Potter's yard; aluminum tablet stamped "8842.5"	8,842.128
Dallas, 6.8 miles west of, 100 feet east of fence corner, in small sandstone 10 feet north of highway; aluminum tablet	8,899.546

Cimarron south along highway to Jackson.[1]

Cimarron, 325 feet west of milepost "D 329," 25 feet west of water tank, 15 feet west of track, in stone; aluminum tablet	6,892.265
Cimarron, 2.5 miles south of, 150 feet southeast of house, west side of road, in large bowlder; aluminum tablet stamped "7044 1909"	7,041.478
Cimarron, 3.7 miles south of, 100 feet northwest of intersection of road up mesa, in root of tree at gateway on west side of road; copper nail marked "7110 B. M."	7,107.66
Cimarron, 5.6 miles south of, 70 feet southwest of small bridge, 130 feet north of John Whittingham's house, in bowlder; aluminum tablet stamped "7341 1909"	7,338.579
Whittingham's ranch, 4 miles south of, 100 feet south of bridge over ditch, east side of road, in large bowlder; aluminum tablet stamped "8399 1909"	8,397.129
Whittingham's ranch, 6.2 miles southwest of, 400 feet south of house on cattle ranch, 10 feet north of northeast corner of bridge over ditch, mark on bowlder; marked "8418"	8,415.41
Loback's cattle ranch, 1.6 miles south of, 80 feet west of ditch, 20 feet west of road, in large bowlder; aluminum tablet stamped "8441 B. M."	8,439.481
Jackson, 6.8 miles north of, 15 feet west of road, near growth of small trees, in bowlder; aluminum tablet stamped "8381 1909"	8,379.163
Jackson, 5 miles north of, 200 feet west of ford, 80 feet southwest of bend in road, in bowlder; aluminum tablet stamped "8672 1909"	8,670.665
Jackson, 1.5 miles northwest of, on divide 0.7 mile south of junction of Cimarron and Little Cimarron creeks, 15 feet south of trail, in small bowlder; bronze tablet stamped "8979 OURAY"	8,974.407

Milepost 325 west along Denver & Rio Grande R. R. to Montrose.

Cimarron, 3.1 miles east of, 2 feet northeast of milepost "D 326" in stone; aluminum tablet	6,873.111
Cimarron, 15 feet west of track, 325 feet west of milepost "D 329," 25 feet west of water tank, in stone 15 feet west of track; aluminum tablet	6,892.265
Cimarron, 3 miles west of, 50 feet west of milepost "D 332," 20 feet north of track, in rock; aluminum tablet	7,471.274
Cimarron, 6.1 miles west of, 6 feet west of track, 20 feet southeast of milepost "D 335", in bowlder; aluminum tablet	7,908.806

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[1] An excessive error was distributed in this line.

	Feet.
Cedar Creek, 3.3 miles east of, 20 feet north of track, 40 feet west of milepost "D 338", in bowlder; aluminum tablet	7, 319. 242
Cedar Creek, at station, 20 feet east of track, in second foundation pier of water tank; aluminum tablet	6, 732. 772
Lujane, at west portal of Gunnison tunnel, 70 feet south of fifth telegraph pole east of milepost "D 343"; iron post (Reclamation Service elevation 6,550.919)	6, 531. 322
Lujane, 1.5 miles west of, 10 feet north of track, 1,200 feet west of milepost "D 344", in bowlder; aluminum tablet	6, 345. 685
Fairview, 1.3 miles west of, 10 feet west of road, 75 feet west of track, in east side of foundation of large water tank; aluminum tablet stamped "6009"	6, 004. 734
Montrose, 0.6 mile east of, 20 feet west of switch block of branch to Ouray; iron post stamped "5858 U. S. R. S. B. M." (Reclamation Service bench mark)	5, 837. 99

Uncompahgre Valley; Gunnison project.

The following Geological Survey bench marks were established by the Reclamation Service. The bench marks, marked with asterisks (*), were redetermined by the United States Geological Survey, and the elevations given for them are the results of Geological Survey adjusted leveling. The other elevations, presumed to be approximately in agreement, were determined by subtracting 19.2 feet from Reclamation Service values.

	Feet.
Cedar Creek, at station (1.732 feet below bench mark established by the Geological Survey); iron post	6, 731. 040
* Cedar Creek, 1.6 miles west of; iron post (Reclamation Service bench mark)	6, 531. 322
*Fairview, 4 feet northwest of signpost marked "Fairview siding," between Lujane and Montrose on narrow gage line of Denver & Rio Grande R. R. to Salida; iron post	6, 146. 476
*Montrose, 1 mile south of, 7 feet east of switch stand, at east end of Y; iron post	5, 837. 99
T. 49 N., R. 9 W., 1.5 feet south of southeast corner of NE. ¼ NE. ¼ sec. 36, about 0.25 mile northwest of ditch, 0.8 mile south of main line of narrow gage railroad from Montrose to Salida, set 3 feet in earth under signal at south base; iron post	6, 107. 078
Dry Cedar Creek, 25 feet southwest of bridge where road up Dry Cedar Creek crosses the High Line canal, 15 feet south of High Line canal and 15 feet north of lateral of the Cimarron ditch; iron post	6, 114. 479
Montrose & Delta canal, 13.8 feet from center of head gate, at southeast corner of section house, set 1 foot under surface of ground; iron post	6, 090. 771
Uncompahgre River, high ridge on west side of, 1 mile west of narrow gage track Montrose to Ouray, in saddle about 700 feet southeast of end of ridge, 50 feet east of road, in rock 3 by 3.5 by 2 feet; metal plate (Montrose & Delta canal passes around end of ridge, and is about 80 feet below this bench mark)	6, 126. 629
Montrose & Delta canal, bridge at crossing of Pinyon road, 2 feet north of telegraph pole 50 feet fron canal and 75 feet south of southeast corner of bridge; iron post	6, 014. 980

	Feet.
Montrose & Delta canal, near bottom of Coal Creek drop, 30 feet south of south bank of canal, 20 feet west of large bowlder, 20 feet north of 14-inch cedar tree; iron post	5,836.871
Montrose & Delta canal, at top of Coal Creek drop, on sandstone ledge 30 feet southwest of jump-off, 25 feet south of blazed cedar tree; metal plate	5,949.477
Oak Grove, 35 feet northeast of northwest corner of schoolhouse, 12 feet west of line to center of double door; iron post	5,928.572

LAKE CITY 15′ (UNCOMPAHGRE PEAK 30′) QUADRANGLE.

North Fork of Henson Creek north over divide and down Cimarron Creek to Jacksonville.

Capitol City, 2 miles northwest of, 300 feet northwest of forks of road leading to Guilneau's sawmill, 20 feet northeast of road beside monument, in granite bowlder; bronze tablet stamped "10436 OURAY"	10,432.266
Capitol City, 5 miles north of, on divide between North Fork of Henson Creek and Cimarron Creek, 0.6 mile southwest of Matterhorn Peak, 1.2 miles east of Wetterhorn Peak and 1.5 miles southwest of Uncompahgre Peak, 15 feet south of trail near its forks, 330 yards south of Sullivan's cabin, in granite rock; bronze tablet stamped "12463 OURAY"	12,458.909
Capitol City, 8 miles north of, 0.5 mile north of Philips's cabin, 200 feet south of ruins of large cabin, 2 feet above ground, east side of Cimarron Creek, 6 feet west of trail, in bowlder; bronze tablet stamped "10773 OURAY"	10,768.875
Jacksonville, 4.5 miles south of, 300 feet southeast of junction of Middle and South forks of Cimarron Creek, east of trail, in conglomerate bowlder; bronze tablet stamped "9924 OURAY"	9,919.900
Jacksonville, 1.5 miles south of, 20 feet west of trail, in bowlder 5 by 5 feet and 3 feet high; bronze tablet stamped "9207 OURAY"	9,202.684

Point 2 miles northwest of Capitol City down Henson Creek east to Lake City (line run twice).

Capitol City, 0.4 mile northwest of, road up north fork of Henson Creek, 7 feet south of road, in outcropping bowlder; aluminum tablet stamped "9957 OURAY"	9,952.687
Capitol City, 60 feet northeast of two-story brick house, 50 feet south of street, in northeast corner of city, in trachyte bowlder; aluminum tablet stamped "9667 OURAY"	9,662.994
Capitol City, 3.1 miles east of, 18 feet north of Henson Creek, 8 feet south of road to Lake City, in 8 by 5 by 4 foot trachyte bowlder; aluminum tablet stamped "9414 OURAY"	9,409.668
Henson, 12 feet east of post office, 12 feet south of road, in middle of settlement at Ute & Ulay mine, in outcropping ledge; bronze tablet stamped "9203 OURAY"	9,198.654
Lake City, Miners & Merchants Bank, at front entrance to, in stone pillar; bronze tablet stamped "8681 OURAY"	8,676.402
Lake City, in southwest corner of yard of Lake City schoolhouse, 110 feet southwest of brick schoolhouse; bronze tablet stamped "8663 OURAY"	8,658.659

Lake City north down Lake Fork of Gunnison River to point 4 miles north of Youman (line run twice).

	Feet.
Lake City, 0.7 mile north of, 600 feet northwest of cemetery, 15 feet west of road down Lake Fork, at top of hill, in granite bowlder 3 by 2 by 2 feet; aluminum tablet stamped "8758 OURAY"	8,753.863
Lake City, 4.8 miles north of, 20 feet west of road, 200 yards south of entrance to canyon, opposite brick house on Baker ranch, in trachyte bowlder 8 by 5 by 4 feet; bronze tablet stamped "8515 OURAY"	8,510.239
Youman, 2.4 miles south of, 200 yards east of Nine Mile ranch, 15 feet west of road, in mound of stone; iron post stamped "8527 OURAY"	8,522.396
Youman, 100 yards south of Youman water tank, 60 feet north of section house, 30 feet east of railroad track, 12 feet east of road; iron post stamped "8321 OURAY"	8,315.831
Kellog siding, 0.8 mile north of, 100 feet south of railroad, 80 feet northwest of bowlder 20 by 20 by 12 feet, 200 feet southeast of outcropping bowlder 3 by 3 by 1.5 feet in bowlder; bronze tablet stamped "8188 OURAY"	8,182.571
Kellog siding, 1.8 miles north of, 400 feet northwest of milepost 336, 50 feet west of railroad, 25 feet east of wagon road, 100 yards north of small butte with conical rock on top, in mound of stone; iron post stamped "8131 OURAY"	8,126.121

UNCOMPAHGRE PEAK QUADRANGLE.

Kellogg siding north along Denver & Rio Grande R. R. (Lake City branch) to point near Dayton, thence along road east to Powderhorn and south to Slumgullion Pass.

Spruce Point, at north end of switch, west of track, top of rock; marked "8074.13"	8,070.18
Spruce, 2.4 miles north of, 40 feet northeast of small bridge over stream, about 1,000 feet east of Denver & Rio Grande R. R. up the arroya, 30 feet from top of ridge, in top of bowlder; aluminum tablet	8,039.431
Gate View ranch, 20 feet from southeast corner of ranch house, in rock at road intersection; aluminum tablet	7,949.693
Gate View ranch, 4.7 miles east of, 5 feet south of center of road at summit between Gate View ranch and Powderhorn, in ledge of rocks; aluminum tablet	8,927.512
Powderhorn, 2.2 miles southwest of, 10 feet south of road, 500 feet northwest from intersection of Powderhorn and Sapinero roads; point on rock marked "8593.90"	8,589.99
Powderhorn, 250 feet east of post office, at road intersection, in ledge of rock; aluminum tablet	8,053.742
Powderhorn, 4 miles east of, 1 foot inside fence, 15 feet from southeast corner of William Sammon's house on Beaver Creek, in small rock; aluminum tablet	8,231.842
Sammon's ranch, 3 miles southeast of, 0.5 mile north of Johnson's ranch, south of road, at rocky point at bend in road, 20 feet north of fence corner, 3 feet outside fence, in bowlder; aluminum tablet	8,344.007
Cebolla Creek bridge, 30 feet southwest of, 5 feet east of road, 30 feet southeast of ford, in large bowlder; aluminum tablet	8,529.381

	Feet.
Warrant's ranch, at mouth of Rock Creek, 700 feet south of, 5 feet east of road, in ledge of rock; aluminum tablet	8, 749. 156
Warrant's ranch, 1 mile south of, 25 feet from west side of road, in top of stump; spike marked "8809.29"	8, 805. 53
Cathedral, 0.25 mile northwest of post office, 100 feet northwest of road forks, 20 feet east of edge of mesa, near mouth of Spring Creek, in top of bowlder; aluminum tablet	8, 908. 152
Howard's ranch, 4.3 miles southwest of mouth of Spring Creek, 20 feet east of spring house, in rock; aluminum tablet	9, 139. 541
Howard's ranch, 3 miles southwest of, 0.5 mile southwest of entrance of second canyon from Howard's ranch, west of trail, 75 feet southwest of small stream, in top of large bowlder; aluminum tablet	9, 482. 439
Howard's ranch, 6.2 miles southwest of, 2 feet from southeast corner of bowlder about 1 cubic yard in size, 25 feet west of trail, 35 feet west of Mill Creek, at southwest end of cliffs, 0.5 mile from south of Mill Creek, in small flat rock; aluminum tablet	10, 023. 989

Powderhorn north along road to Iola, thence west along Denver & Rio Grande R. R. to Sapinero.

Powderhorn, 3.4 miles northeast of, at stone monument 3 feet high, 75 feet west of road, on small ridge 1,000 feet northwest of peak on east side of road, about 1 mile south of Old Lot mine, in small flat stone; aluminum tablet	8, 484. 154
Powderhorn, 6.1 miles northeast of, 50 feet southeast of fork of road to Spencer, 20 feet east of Iola road, in ledge of rock; aluminum tablet	8, 915. 727
Ninemile Hill, 100 feet east of road at summit, point on small ledge of rock; marked "8970.64"	8, 966. 79
Ninemile Hill, 0.8 mile northeast of, 75 feet east of forks of old and new road, 600 feet east of rocky point on west side of road, in ledge of rocks; aluminum tablet	8, 746. 712
Big Spring ranch, 0.8 mile northeast of entrance, 300 feet east of road, 50 feet east of small swamp, in ledge of rock; aluminum tablet	8, 253. 577
Iola, 2.1 miles south of, 30 feet west of road, on side of small knoll, 40 feet east of top, in ledge of rock marked by mound of stone; aluminum tablet	7, 770. 092
Iola, 14 feet north of the northwest corner of annex to Iola Hotel, in ledge of rock; aluminum tablet	7, 453. 764
Iola, 2.8 miles west of, 300 feet southwest of milepost "D 302," 45 feet south of track, in ledge of rock; aluminum tablet	7, 401. 510
Iola, 4.7 miles west of, in base of milepost "D 304"; spike marked "7367. 81" (railroad bench mark)	7, 363. 43
Iola, 5.8 miles west of, 125 feet west of milepost "D 305", 20 feet west of water tank, 15 feet north of track at Elk Creek, in small bowlder; aluminum tablet	7, 356. 206
Cebolla, 1.1 miles west of, 600 feet southwest of milepost "D 308", 40 feet south of track at rock cut, 20 feet from bank of river, in ledge of rock; aluminum tablet	7, 312. 422
Cebolla, 2.9 miles west of, in side of milepost "D 310"; spike marked "7292.48" (railroad bench mark)	7, 288. 06
Cebolla, 4 miles northwest of, 125 feet west of milepost "D 311", 15 feet north of track, in ledge of rocks; aluminum tablet	7, 272. 371

	Feet.
Cebolla, 5 miles west of, in base of milepost "D 312"; spike marked "7264.14" (railroad bench mark)	7,259.71
Cebolla, 6 miles west of, in base of milepost "D 313"; spike marked "7245.55" (railroad bench mark)	7,241.16
Sapinero, 100 feet north of north end of county bridge over Gunnison River, 15 feet east of road, 850 feet southwest of end of switch at Y, 450 feet south of main track of the Denver & Rio Grande R. R. in ledge of rocks; aluminum tablet	7,238.006

Iola east along Denver & Rio Grande R. R. to point near Elkhorn station (double spur line).

Elkhorn, 600 feet east of station, at the 10-mile bridge, in side of milepost "D 297"; spike marked "7484.98" (railroad bench mark)	7,480.66
Elkhorn, 0.8 mile east of, 25 feet north of track, on edge of Gunnison River, 300 feet east of rocky point on sharp curve, 0.2 mile west of milepost "D 296", in top of large bowlder; aluminum tablet	7,491.980

Gate View ranch northwest along road to forks of roads to Montrose and Sapinero, thence northeast to Sapinero.

Gate View ranch, 1 mile northwest of, 15 feet west of road, 300 feet southwest of schoolhouse; point on bowlder marked "7817.14"	7,813.03
Gate View ranch, 3 miles northwest of, 2 feet west of road, 150 feet southeast of bend in road, in bowlder; aluminum tablet	8,077.579
Gate View ranch, 6 miles northwest of, on top of knoll 30 feet northeast of road on top of hill, in top of ledge of rocks; aluminum tablet	8,878.148
Willow Creek, 1.5 miles west of, 10 feet southwest of road, at top of hill, in large flat rock; aluminum tablet	8,848.044
Willow Creek, 4.4 miles west of, 30 feet west of road at top of hill about 0.7 mile west of Pine Creek, in small flat rock; aluminum tablet	8,901.014
Forks of roads to Montrose and Sapinero, 2.7 miles northeast of, 25 feet southeast of road, 5 feet northwest of trail, 100 feet east of forks of road and trail, 400 feet west of ford of Pine Creek, in large bowlder; aluminum tablet	8,224.748

Forks of Montrose and Sapinero roads west to junction of Little Blue and Big Blue creeks (double spur line).

Forks of Montrose and Sapinero roads, 2.2 miles west of, 3 feet south of road, 150 feet southwest of junction of Little and Big Blue creeks, in bowlder; aluminum tablet	8,197.688

Sapinero east on Powderhorn road (double spur line.).

Sapinero, 3.2 miles southeast of, on top of knoll 40 feet south of road, 300 feet west of road forks of abandoned road, marked by mound of stone, in small rock flush with ground; aluminum tablet	7,800.336
Sapinero, 6 miles southeast of, 30 feet west of road on top of small knoll, 40 feet south of small arroyo, 400 feet west of large arroyo, marked by mound of stone, in small flat rock; aluminum tablet	8,161.029

Sapinero northwest along road 4.5 miles (single spur line).

Sapinero, 3.1 miles northwest of, at top of needle on rim of Black Canyon, at small pine tree, 300 feet south of road at bend, between two small canyons, in rock; aluminum tablet	7,623.908

	Feet.
Sapinero, 4.4 miles northwest of, 3 feet south of road, 150 feet east of creek, 100 feet northwest of ruins of stone house, in top of small cone-shaped rock; aluminum tablet	7,829.962

Sapinero west along Denver & Rio Grande R. R. to milepost 325.

Sapinero, 0.8 mile west of, in base of milepost "D 315"; spike marked "7221.25" (railroad bench mark)	7,216.79
Sapinero, 2.7 miles east of, 15 feet west of track, 20 feet south of milepost "D 317", in large bowlder; aluminum tablet	7,170.150
Sapinero, 5.6 miles west of, 3 feet north of milepost "D 320", in bowlder; aluminum tablet	7,004.451
Sapinero, 8.6 miles west of, 50 feet west of milepost "D 323", in small bowlder; aluminum tablet	6,984.039

Creede, Engineer Mountain, Needle Mountains, Rico, and Silverton 15′ quadrangles, and San Cristobal 30′ quadrangle.

DOLORES, HINSDALE, LA PLATA, MINERAL, OURAY, AND SAN JUAN COUNTIES.

The elevations in the following list are based upon heights of bench marks at Montrose, Colo., established by precise leveling of the United States Geological Survey, and at Albuquerque, N. Mex., established by precise leveling of the Coast and Geodetic Survey, the connection being made by the primary level net.

The leveling in the Creede quadrangle was done in 1904 by J. E. Chapson; that in the San Cristobal quadrangle in 1899 by T. Winsor and in 1904 by Chapson; that in the Silverton quadrangle in 1899 by Winsor and in 1901 by Chester Irvine; that in the Needle Mountains quadrangle in 1898 by T. Winsor and in 1900 by J. P. Darling; that in the Engineer Mountain quadrangle in 1896 by C. W. Beach, in 1897 by A. L. Fellows, and in 1898 by Winsor; and that in the Rico quadrangle in 1898 by Winsor.

The considerable error in stamped elevations is due to the assumed datums upon which the field work was done.

CREEDE QUADRANGLE.

Point 3 miles northeast of Antelope northeast to Lower Creede.

	Feet.
Antelope Springs, 6 miles northeast of, 20 feet east of road, 100 feet south of forks of road, 650 feet north of southeast corner of pasture; iron post stamped "8762 OURAY"	8,757.780
Fivemile bridge, 1.6 miles east of, 150 feet west of junction of Silverton and Sunnyside roads, 100 feet east of bridge over irrigating ditch, 60 feet north of road; iron post stamped "8682 OURAY"	8,677.920
Lower Creede, south part of town, 80 feet east of Denver & Rio Grande R. R. track, 150 feet north of section house, 120 feet west of Main Street; iron post stamped "8780 OURAY"	8,775.262

Point 2 miles north of Lime Creek northeast to Lower Creede.

Sevenmile bridge, 1 mile northeast of, 30 feet northwest of road, in 6 by 4 by 3 foot bowlder; aluminum tablet stamped "8759 OURAY"	8,754.828

	Feet.
Lower Creede, 3.2 miles south of, 100 feet south of side grade of Denver & Rio Grande R. R. bridge, 100 feet east of wire fence, 20 feet southeast of road; iron post stamped "8708 OURAY"	8,703.727
Lower Creede, in old Maben Bank building, near south entrance; aluminum tablet stamped "8854 OURAY"	8,849.640

Lower Creede via Bachelor, Park Regent mine, Phoenix Park, and East Willow Creek to Lower Creede.

Lower Creede, 1.2 miles northwest of, 100 yards north of switchback, 70 feet west of road, in 4 by 4 by 2 foot bowlder; aluminum tablet stamped "9812 OURAY"	9,808.193
Bachelor, east side of principal street, 40 feet north of town well; iron post stamped "10531 OURAY"	10,527.537
Park Regent mine, 100 yards southeast of, 30 feet west of road, in bowlder; aluminum tablet stamped "10454 OURAY"	10,450.496
Park Regent mine, 1.1 miles east of, 900 feet north of east branch of West Willow Creek, at old sawmill site, 20 feet east of road, in 4 by 2 by 2 foot bowlder; aluminum tablet stamped "10260 OURAY"	10,256.303
Campbell Ridge, summit of, between East and West Willow creeks, in ledge with dead bearing tree north of road; aluminum tablet stamped "10601 OURAY"	10,597.599
Phoenix Park, in south part of, 200 feet southeast of cabin, 150 feet west of road up East Willow Creek; iron post stamped "9709 OURAY"	9,705.390
Mollie S. mine, 60 feet south of tram house, 20 feet east of East Willow Creek, 12 feet east of road, in 8 by 8 by 4 foot bowlder; aluminum tablet stamped "9160 OURAY"	9,156.248

SAN CRISTOBAL QUADRANGLE.

Lake San Cristobal southwest along road up Gunnison River (Lake Fork) to Sherman, thence northwest to Whitecross.

Lake San Cristobal, 45 feet north of north end of lake, 40 feet east of road, 600 feet northeast of Golden Fleece tunnel; iron post stamped "9000 OURAY"	8,995.653
Lake San Cristobal, 0.25 mile southwest of south end, 10 feet west of State road, in trachyte bowlder 4 by 1 by 3 feet; aluminum tablet stamped "9021 OURAY"	9,016.731
Lake San Cristobal, 3.5 miles southwest of south end, 30 feet east of junction of State road and road to Clawson's ranch, 30 feet south of small stream, in top of cropping syenite bowlder; aluminum tablet stamped "9180 OURAY"	9,175.603
Wager Gulch. mouth of, on Gunnison River, 0.3 mile south of Capt. Hall's house, 15 feet south of junction of Silverton and Carson City roads, 200 feet south of river, in front of log cabin; iron post stamped "9350 OURAY"	9,345.303
Sherman, in east end of town, 200 feet south of where State road starts up mountain side; iron post stamped "9552 OURAY"	9,547.836
Sherman, 3.5 miles northwest of, 300 feet north of river, 10 feet south of road, in ledge; aluminum tablet stamped "10270 OURAY"	10,266.724
Whitecross, 1.5 miles east of, 100 feet east of Cooper Creek, at Argentum, in bowlder 3 by 3 feet by 6 inches; aluminum tablet stamped "10564 OURAY"	10,559.759

	Feet.
Whitecross, 10 feet south of road, 150 feet north of creek, 650 feet northeast of La Belle power house; iron post stamped "10754 OURAY"	10, 750. 439

Gunnison River south via Carson to Rio Grande.

Carson Pass, 2.3 miles north or, in iron bed flats, 400 feet south of placer diggings, 6 feet west of road, in bowlder; aluminum tablet stamped "11273 OURAY"	11, 269. 837
Carson Pass, summit of, 75 feet west of road; iron post stamped "12360 OURAY"	12, 357. 281
Carson Pass, 3.5 miles south of, 200 feet above and 650 feet east of Lost Trail Creek, where trail leaves pack and enters spruce timber, 5 feet east of trail, in bowlder 5 by 1 by 3 feet; aluminum tablet stamped "11224 OURAY"	11, 220. 303
Carson Pass, 6.2 miles south of, 500 feet south of junction of East and West Lost Trail creeks, 5 feet west of trail, in 4 by 4 by 1 foot bowlder; aluminum tablet stamped "10307 OURAY"	10, 303. 182

Down Rio Grande east to Antelope Springs.

Point Burwell, 0.3 mile northwest of, 50 feet southeast of old log cabin, 25 feet south of road, in top of large rock; aluminum tablet stamped "9486 DUR"	9, 493. 108
Point Burwell, 0.05 mile northwest of, in grassy flat, near large post marked "Point Burwell," 30 feet north of wagon road; iron post stamped "9479 OURAY"	9, 474. 734
Point Burwell, 3.3 miles southeast of, at base of steep slope, 75 feet north of road at point where Rio Grande makes a sweep in bend, on bench of rock ledge; aluminum tablet stamped "9384 DUR" (old bench mark)	9, 391. 187
Point Burwell, 4.1 miles south of, 100 yards south of log cabin, 200 yards north of Rio Grande ford, 50 feet west of base of bluff, 20 feet east of road, in grassy flat; iron post stamped "9386 OURAY"	9, 381. 579
Weminuche Creek, 2.1 miles east of, 80 feet north of road, 50 feet south of river, in grassy park, in 5 by 5 by 4 foot bowlder; aluminum tablet stamped "9321 OURAY"	9, 316. 573
Two Lakes Creek, 1.8 miles west of, 500 feet east of head of long park, 150 feet east of old chimney of burned cabin; iron post stamped "9441 OURAY"	9, 437. 531
Two Lakes Creek, 1.1 miles southeast of, in long park, 25 feet east of road, in bowlder 8 by 6 by 4 feet; aluminum tablet stamped "9275 OURAY"	9, 271. 056
Antelope Park, west edge of, 300 yards west of buildings on San Juan ranch, 50 feet north of northwest corner of ranch fence, 30 feet north of road; iron post stamped "9039 OURAY"	9, 034. 998
Antelope Park, 150 feet southeast of Brown's ranch, 40 feet north of road; iron post stamped "9001 OURAY"	8, 996. 874
Antelope Park, 20 yards west of old stage station, 20 feet south of low cliff of rocks, 20 feet north of road; iron post stamped "8938 OURAY"	8, 933. 400
Soward ranch, 0.2 mile north of Rio Grande, 20 feet east of road, at ranch road to house; iron post stamped "8928 OURAY"	8, 924. 108
Antelope Springs, 50 feet north of; iron post stamped "8960 OURAY"	8, 956. 218

Antelope Springs northwest along road via Lake Santa Maria, Clear Creek, Cebolla Pass, and Slumgullion Gulch to Lake San Cristobal.

	Feet.
Lake Santa Maria, 0.7 mile east of, 25 feet south of road, near highest point of Santa Maria Pass, in bowlder 3 by 1 by 3 feet; aluminum tablet stamped "9695 OURAY"	9, 691. 438
Lake Santa Maria, on contour line as surveyed by Equitable Life Insurance Co. for reservoir, near the company's station XXII; iron post stamped "9475 OURAY"	9, 470. 888
Boulder Creek dam, 300 feet west of, 0.2 mile west of old Lakeman fishpond, 30 feet south of road, in 15 by 10 by 4 foot bowlder; aluminum tablet stamped "9705 OURAY"	9, 702. 386
Clear Creek falls, 0.1 mile southwest of, 12 feet south of road; iron post stamped "10052 OURAY"	10, 048. 283
Clear Creek crossing, 2 miles north of, 650 feet west of Big Spring Gulch Creek, 40 feet west of road, in bowlder 8 by 5 by 3 feet; aluminum tablet stamped "10344 OURAY"	10, 340. 353
Continental Divide, summit of, between Big Spring Gulch and Cebolla Creek, 50 feet east of road, 30 feet east of Lakeman ditch; iron post stamped "10901 OURAY"	10, 897. 289
Cebolla Creek, 450 feet southwest of southwest branch, 15 feet east of road, in 4 by 2 by 1 foot bowlder; aluminum tablet stamped "10394 OURAY"	10, 390. 354
Slumgullion Pass, 2.5 miles south of, 20 feet south of corduroy roads, in 4 by 4 by 2 foot blue bowlder; aluminum tablet stamped "11124 OURAY"	11, 120. 212
Slumgullion Pass, 0.5 mile west of, in Slumgullion Gulch, 100 feet south of road, at white dump from old tunnel, 30 feet east of sawdust pile at old mill site, in bowlder; aluminum tablet stamped "11005 OURAY" (1909 value from Montrose=11,001.654 feet)	11, 001. 504
Slumgullion Pass, 3.1 miles west of, 8 feet southwest of road in elbow of switchback, in 3 by 2 by 2 granite rock; aluminum tablet stamped "9762 OURAY"	9, 757. 612

Antelope Springs northeast 3 miles along road toward Lower Creede.

Antelope Springs, 3 miles east of, 40 feet southeast of road, 350 yards southwest of side grade by river, in large triangular bowlder 4 by 4 by 4 feet; aluminum tablet stamped "8863 OURAY"	8, 858. 885

Soward ranch along roads south of Rio Grande to point 2 miles north of Lime Creek.

Lime Creek, 450 feet west of, 900 feet south of river at great bend, 0.3 mile southeast of Kansas clubhouse, 1 mile northeast of Soward's house, at junction of road to south, river pass; iron post stamped "8912 OURAY"	8, 907. 550
Lime Creek, 2 miles north of, 20 feet west of road, in 4 by 4 by 3 foot bowlder; aluminum tablet stamped "8930 OURAY"	8, 926. 218

Lost Trail Creek east along trail down Clear Creek to Clear Creek Falls.

Rube Harris's ranch house, 0.2 mile northwest of, 200 yards southwest of small reservoir, 15 feet north of trail, in 4 by 4 by 2 foot bowlder; aluminum tablet stamped "10417 OURAY"	10, 413. 156
Swanks Lake, 50 yards northeast of north end of dam, 12 feet southeast of road; iron post stamped "10331 OURAY"	10, 327. 078

	Feet.
Swanks ranch, 1.2 miles northeast of house, 65 feet north of junction of roads to Creede and Lake City; iron post stamped "10287 OURAY"	10,282.784
Swanks ranch, 4.1 miles northeast of, 300 feet southeast of gorge, 20 feet north of road, 40 feet south of Clear Creek; iron post stamped "10211 OURAY"	10,207.139
Swanks ranch, 6.1 miles east of, 100 feet south of junction of road with spur from Horse Thief trail, 600 feet east of creek, 600 feet northeast of rocky butte; iron post stamped "10143 OURAY"	10,138.658
Clear Creek crossing, 0.4 mile northwest of, 100 feet west of irrigating ditch, 20 feet west of road, in 2 by 2 by 1 foot bowlder with mound of rock alongside; aluminum tablet stamped "10065 OURAY"	10,061.224

Clear Creek crossing above falls south along road to San Juan ranch.

Divide between South Clear Creek and Rio Grande, 100 yards north of, 50 feet east of road, in 10 by 6 by 4 foot bowlder; aluminum tablet stamped "9530 OURAY"	9,526.315

Forks of road to Emerald Lakes north to Point Burwell.

Los Pinos River, 0.2 mile southwest of mouth of Falls Creek, 12 miles northeast of Graham's ranch, southeast of trail, in front of 8-inch spruce tree, about 400 feet west of high waterfall on side of mountain, in top of pink granite bowlder; bronze tablet stamped "8700 DUR"	8,706.575
Flint Fork, 0.25 mile south of mouth of, on east side of trail, near summit of steep ascent on south side of Flint Fork Canyon, in top of large granite bowlder; bronze tablet stamped "9323 DUR"	9,329.723
Flint Fork, 2.75 miles northeast of mouth of, southeast of trail near clump of spruce trees, about 100 feet northeast of small mountain stream, in top of granite bowlder; bronze tablet stamped "9904 DUR"	9,909.683
Weminuche Pass, 4 miles southwest of, on east side of and nearly level with trail, in top of granite bowlder; bronze tablet stamped "10050 DUR"	10,056.987
Weminuche Pass, 9 feet east of trail, 150 feet south of summit of Continental Divide, in top of sandstone bowlder; aluminum tablet stamped "10622 DUR"	10,628.774
Weminuche Pass, 1.8 miles northeast of, 10 feet northeast of small creek, 60 feet southwest of blazed twin spruce tree on southeast side of trail, in triangular-shaped bowlder; aluminum tablet stamped "10336 DUR"	10,342.876

Mouth of Lost Trail Creek west up Rio Grande to Pole Creek.

Point Burwell, 3 miles northwest of, 8 feet south of and nearly level with road on side of hill, in top of sandstone rock; aluminum tablet stamped "9916 DUR"	9,923.063
Timber Hill, 1.5 miles east of, 45 feet north of road near cow camp at base of hill, 2 feet above ground, in southwest face of large wedge-shaped rock 12 feet high; aluminum tablet stamped "9989 DUR"	9,995.999
Timber Hill, 1.7 miles northwest of, on edge of rocky mound, east side of road, 120 feet north of Pole Creek, in top of bowlder; aluminum tablet stamped "10486 DUR"	10,492.758

Rio Grande west 1 mile up Bear Creek.

	Feet.
Beartown, 3 miles northeast of, 200 feet northeast of spring branch, 1 foot to north of road, in bowlder; bronze tablet stamped "10623 DUR"	10, 629. 275

SILVERTON QUADRANGLE.

Tollgate south of Ouray east via Bear Creek to American Flat.

Ouray, 5.9 miles southeast of, 150 feet south of Bear Creek trail at southwest corner of main cabin at Camp Snyder, in bowlder; bronze tablet stamped "10839 OURAY"	10, 837. 088
Ouray, 8.5 miles southeast of, 40 feet south of trail at crossing of range, head of Bear Creek and west of American Flat, in bowlder; bronze tablet stamped "12630 OURAY"	12, 628. 798

Point near Timber Hill northwest along road to Howardsville, thence southwest to Silverton and south to Molas Lake.

Stony Pass, 2.5 miles southeast of, on north side of road, 50 feet east of trail, 170 feet east of sharp bend in road, in top of bowlder; bronze tablet stamped "11473 DUR"	11, 477. 889
Stony Pass, summit of, 15 feet northeast of road, in top of flat rock; aluminum tablet stamped "12594 DUR"	12, 598. 505
Howardsville, 1.7 miles southeast of, on south side of road, 150 feet east of junction with road running south up Cunningham Gulch, in top of large rock; bronze tablet stamped "10096 DUR"	10, 100.909
Howardsville, 400 feet south of post office, on south side of road at forks, 100 feet south of bridge over Cunningham Creek, in top of bowlder; aluminum tablet stamped "9670 DUR"	9, 674. 705
Silverton, 2.3 miles northeast of, on south side of public road, 15 feet north of track, 120 feet east of road crossing, about 400 feet northeast of E. G. Stoiler's residence, on top of quartz bowlder; aluminum tablet stamped "9431 DUR"	9, 435. 502
Silverton, in southeast corner of Grand Hotel block, 2.5 feet above sidewalk, at northwest corner of Greene and Twelfth streets; aluminum tablet stamped "9302 DUR"	9, 306. 334
Silverton, at northwest corner of section house on opposite side of track from Denver & Rio Grande R. R. station; iron post stamped "9270 DUR"	9, 274. 565

NEEDLE MOUNTAINS QUADRANGLE.

Point 2 miles north of fish hatchery north up Vallecito Creek, over divide, and down Bear Creek to its mouth.

Quartz mill, 0.5 mile north of, 90 feet north of prospect dump on trail and 150 feet south of junction of two branches of Vallecito Creek, in top of point of rock jutting into creek; aluminum tablet stamped "8426 DUR"	8, 432. 278
Quartz mill, 3.7 miles northeast of, 300 feet south of creek crossing, foot of hill on west side of creek, 3 feet left of trail, in bowlder; aluminum tablet stamped "8869 DUR"	8, 875. 000
Johnson Creek, 75 feet south of, 250 feet west of its junction with Vallecito Creek, in granite bowlder; aluminum tablet stamped "9166 DUR"	9, 172. 723

	Feet.
Vallecito Creek, west side of, 3 miles northeast of mouth of Johnson Creek, 15 feet west of spring branch, 20 feet east of trail at foot of hill; aluminum tablet stamped "9578 DUR"	9,584.335
Vallecito Creek, west side of, 7.5 miles north of mouth of Johnson Creek, 5 feet west of trail near forks of creek, in large rock; aluminum tablet stamped "10995 DUR"	11,001.395
Hunchback Mountain Pass, summit of, 125 feet northwest of stone monument, 100 feet from west crest of divide; bronze tablet stamped "12487 DUR"	12,493.454
Beartown, lower end of, 125 feet southwest of two lower cabins on north side of road, in bowlder on rocky point; bronze tablet stamped "11157 DUR"	11,162.684

Vallecito Creek west up Johnson Creek 3.5 miles (single spur line).

Johnson and Vallecito creeks, 3.5 miles above junction of, 200 feet south of cabin, in bowlder 30 feet from trail; bronze tablet stamped "11077 DUR"	11,083.722

Point 3 miles northeast of Coal Bank Hill northeast to Molas Lake.

Molas Lake, 2.5 miles southwest of, on west side of road, 1,000 feet south of summit of hill, in top of limestone bowlder 8 feet in diameter; aluminum tablet stamped "10790 DUR"	10,796.701
Molas Lake, 100 feet north of log house on southeast side of Silverton and Cascade toll road, in top of embedded granite bowlder; bronze tablet stamped "10506 DUR"	10,513.237

Point near Molas Lake south along Denver & Rio Grande R. R. (Silverton branch) to point 7 miles north of Rockwood.

Milepost "D 491", 10 feet west of, on top of granite bowlder 5 feet east of track; chiseled cross	9,022.51
Elk Park, 1 mile north of, 350 feet north of milepost "D 490", 20 feet east of track at curve, in top of flat bowlder; aluminum tablet stamped "8924 DUR"	8,930.403
Elk Park, in front of signboard; top of rail	8,874.7
Elk Park, 2 miles south of, 26 feet west of track, opposite milepost "D 487", in granite outcrop; aluminum tablet stamped "8750 DUR"	8,757.097
Needleton, 3 miles north of, 19 feet west of and 4.5 feet below track, 200 feet south of milepost "D 484", in top of granite ledge; aluminum tablet stamped "8430 DUR"	8,436.556
Milepost "D 482", 50 feet northwest of, 7 feet east of track, on granite ledge; chiseled cross	8,230.08
Needleton, 0.25 mile north of, 6 feet west of track, in outcropping rock; aluminum tablet stamped "8142 DUR"	8,148.831
Needleton, in front of platform; top of rail	8,133.8
Needleton, 3 miles southwest of, 9 feet west of track, opposite milepost "D 478", in top of granite ledge; aluminum tablet stamped "7846 DUR"	7,853.102

ENGINEER MOUNTAIN QUADRANGLE.

Rockwood north along Denver & Rio Grande R. R. 7 miles.

	Feet.
Rockwood, 7.4 miles north of, 2.1 miles south of Cascade siding, east side of canyon of Animas River, 3 feet above Denver & Rio Grande R. R. (Silverton branch) and 10 feet from center of track, 800 feet north of milepost 475 D, in face of granite bluff; copper bolt stamped "U. S. G. S.—7587 ft. B. M."	7,594.365

Rockwood north along wagon road to point 3 miles northeast of Coal Bank Hill.

Rockwood, 5.8 miles north of, opposite north end of low limestone butte, 12 feet west of road about two-thirds way up steep hill, 25 feet southeast of blazed quaking aspen and 520 feet south of fence corner (east side), on limestone bowlder 2 by 1 feet; chisled circle	8,699.82
Rockwood, 7.6 miles north of, 30 feet west of road in fence corner, 375 feet south of Elbert Creek, 80 feet southeast of T. Mahon's "Butter ranch;" iron post stamped "8795 DUR"	8,802.106
Columbine Lake; surface of water	8,795
Rockwood, 9.5 miles north of, 0.2 mile south of main road forks, 15 feet east of road, 100 feet southwest of small pond, on sandstone bowlder 2.5 by 4 feet; chiseled square	8,833.73
Cascade Creek bridge, 45 feet north of north end of, 20 feet west of center of road, in granite rock 3 by 4 feet; copper bolt stamped "8721 DUR"	8,727.367
Cascade Creek bridge, 5 miles north of, 8 feet north of road, 14 feet west of 24-inch spruce stump, 75 feet south of summit Coal Bank Hill, in diamond-faced limestone rock 3 by 3 feet; copper bolt stamped "U. S. G. S.—10654—B. M"	10,660.768
Coal Bank Hill, 2.8 miles northeast of, on north side of road 40 feet northeast of bridge over small creek, at point where road makes a horseshoe bend, in top of embedded limestone bowlder; bronze tablet stamped "9642 DUR"	9,649.131

West ranch on Rockwood-Silverton road west to Hermosa Park, thence south down Hermosa Creek to South Fork.

Road forks to Hermosa Park and Silverton, 0.4 mile northwest of, at top of first hill, 3 feet from north edge of outcrop and 25 feet north of road, on flat sandstone ledge; chiseled square	8,972.12
West ranch, 2 miles northwest of, at summit in road between Hermosa Park and Rockwood-Silverton wagon road, 10 feet south of 12-inch spruce, in 2 by 2 foot sandstone bowlder; copper bolt stamped "9805 DUR"	9,811.757
Hermosa Park, 1 mile east of, 12 feet south of center of road, 300 feet west of foot of steep rocky hill, in red sandstone ledge 7 by 7 feet and 2 feet above ground; copper bolt stamped "8898 DUR"	8,905.236
Hermosa Park, center of, 50 feet southwest of bridge over Hermosa Creek, at top of west bank, 0.5 mile north of junction of east fork; iron post stamped "8807 DUR"	8,813.996
Hermosa Park, 1.4 miles south of, 30 feet east of trail at top of high bluff over Hermosa Creek, on sandstone bowlder 2.5 by 2.5 feet; chiseled square	8,808.92

	Feet.
Hermosa Park, 6.4 miles south of, 50 feet northeast by north of 16-inch fir, 80 feet west of 20-inch dead fir near knoll in park, 10 feet west of trail, 50 feet east of creek, 45 feet south of 12-inch spruce, in round red sandstone bowlder 3 feet in diameter; copper bolt stamped "8219 DUR"	8,226.434
Hermosa Park, 10.5 miles south of, at mouth of south fork of Hermosa Creek, near east wall of canyon, 150 feet east of cook cabin at tie camp, 250 feet east of stream forks, 25 feet west by north of 8-inch pine and 30 feet southeast of 15-inch spruce east of trail, in sandstone bowlder 2 by 4 feet and 3 feet above ground; copper bolt stamped "7700 DUR"	7,706.862

Hermosa Park north and west to Scotch Creek and down creek to point near Rico.

Hermosa Park, 1.8 miles north of, 40 feet south of 24-inch spruce tree at mouth of west fork of Hermosa Creek, in white sandstone rock; bronze tablet stamped "8986 DUR"	8,992.709
Hermosa Park, 5.25 miles northwest of, 15 feet southwest of road, at summit of divide between Hermosa Creek and Dolores River; iron post stamped "10413 DUR"	10,419.569
Rico, 6.25 miles southeast of, on north side of road, 300 feet west of where road crosses to north branch of Scotch Creek, in top of red sandstone outcrop; bronze tablet stamped "9247 DUR"	9,253.935

RICO QUADRANGLE.

Down Scotch Creek to Rico.

Rico, 3 miles south of, on north side of road, 150 feet east of forks of road to Durango, in top of conglomerate bowlder; aluminum tablet stamped "8538 DUR"	8,545.005
Rico, 1 mile south of, at forks of road, 150 feet south of south side of cemetery, on granite bowlder; chiseled cross	8,722.79
Rico, in top of west end of balustrade at south side of main entrance to courthouse; aluminum tablet stamped "8824 DUR"	8,831.015
Rico, 50 feet south of Rio Grande Southern R. R. station, near northeast corner of small park; iron post stamped "8714 DUR"	8,720.825

Rico west to summit of Expectation Mountain.

Expectation Mountain, summit of, 20 feet northeast of triangulation station, in top of 15 by 15-inch embedded granite bowlder; bronze tablet stamped "12065 DUR"	12,072.228

Chromo, Ignacio, and Pagosa Springs 30′ quadrangles.

ARCHULETA AND LA PLATA COUNTIES.

The elevations in the following list are based upon primary leveling in this area.

The leveling in the Ignacio quadrangle was done in 1896 by C. W. Beach, in 1899 by T. Winsor, in 1900 by J. P. Darling, in 1906 by A. R. Carver, and in 1907 by F. A. Nussle; that in the Pagosa Springs quadrangle in 1899 by Winsor, in 1906 by Carver, and in 1907 by Nussle; and that in the Chromo quadrangle in 1906 by Carver.

The considerable error in stamped elevations is due mostly to the assumed data upon which the field work was done, and partly to the errors in field computation.

IGNACIO QUADRANGLE.

Durango north to Animas, thence east to Florida Valley.

	Feet.
Durango, Smelter State Bank building, Newman Block, in second course of masonry, southwest corner of foundation; bronze tablet stamped "6517"	6, 524. 351
Durango, in southwest corner of masonry foundation of courthouse, 1.5 feet above ground; bronze tablet stamped "6551"	6, 558. 667
Durango, in front of station, top of rail	6, 510. 0
Animas, 4 miles east of, 40 feet northwest of junction of Animas City and Florida Valley wagon road, on west side of Florida Valley; iron post stamped "7146"	7, 153. 403

Durango northeast to Bluff triangulation station.

Durango, 3.5 miles northeast of, in bed rock 2 feet south of monument, top of highest peak on ridge east of Bluff triangulation station, at head of Horse Gulch; bolt marked "U. S. G. S. 8169 Ft. B. M."	8, 175. 961

Durango west to Lightner Creek, thence north to Junction Creek (spur line).

Durango, 5 miles west of, in forks of Lightner Creek, 80 feet northwest of highway bridge crossing Dry Fork of Lightner Creek; iron post stamped "6944"	6, 951. 274
Animas, 4.5 miles northwest of, 7 feet north of road along Junction Creek and 0.2 mile below deserted sawmill; iron post stamped "7258"	7, 264. 767

Animas north along Denver & Rio Grande R. R. to Rockwood.

Trimble Springs, 2.5 miles south of, in south base of large bowlder 10 by 8 by 6 feet, east side of road running along west side of Animas Valley; iron post stamped "6569"	6, 576. 296
Hermosa, near Denver & Rio Grande R. R. (Silverton branch) station, 125 feet west of tracks on south side of Durango wagon road; iron post stamped "6630"	6, 637. 509
Rockwood, 100 feet north of, within boundaries of railroad Y switch; iron post stamped "7348"	7, 354. 913

Hermosa northwest up Hermosa Creek to South Fork.

Hermosa, 3.5 miles northwest of, 15 feet east of trail, in flat, north of Hermosa Creek; iron post stamped "7709"	7, 716. 529

Point 4 miles east of Animas on Florida River east via Spring Gulch to Columbus.

Nelson's shingle mill, 0.2 mile northeast of, 1.3 miles southwest of schoolhouse, district 14, east side of road, 35 feet north of bridge over head race; iron post stamped "7325 DUR"	7, 332. 040

	Feet.
Stark's sawmill, 1 mile southwest of, on southeast side of road, 10 feet west of gate at entrance to lane leading to Eschoven's residence, 300 feet distant; iron post stamped "7547 DUR"	7, 554. 279
Stark's sawmill, 1.5 miles northeast of, 5 feet south of fence corner, at forks of roads, 100 feet east of bridge over Florida River; iron post stamped "7770 DUR"	7, 776. 961
Columbus, 500 feet west of post office, at forks of road; iron post stamped "7321 DUR"	7, 327. 660

Columbus northeast along Pine River to point 3 miles northeast of Graham ranch.

Columbus, 3 miles northeast of, near angle in rail fence, on east side of road, 200 feet north of bridge over drain; iron post stamped "7496 DUR"	7, 502. 701
Columbus, 6.5 miles north of, by a wire fence, on southeast side of road, at junction with road running up Vallecito Creek; iron post stamped "7617 DUR"	7, 623. 705
Graham's ranch, 0.5 mile southwest of, on north side of road, 17 feet west of bridge over Pine River, near beginning of trail up river, in top of bowlder; aluminum tablet stamped "7747 DUR"	7, 753. 511

Vallecito north up Vallecito Creek to point 2 miles north of fish hatchery.

Fish hatchery, 0.7 mile south of, 250 feet south of small creek, in granite bowlder; aluminum tablet stamped "7720 DUR"	7, 726. 050
Fish hatchery, 2 miles north of, 100 feet south of branch of Vallecito Creek, at foot of large pine tree on west edge of trail, in flat rock; aluminum tablet stamped "7926 DUR"	7, 933. 168

From milepost 413 west along Denver & Rio Grande R. R. to La Boca, thence northwest along railroad to Durango.

Milepost 413, 100 feet south of, on opposite side of track, near telegraph pole, 30 feet south of track, 630 feet southeast of private road crossing and cattle guard; iron post	6, 341. 952
Milepost 415, 500 feet northwest of, 50 feet south of track, 20 feet east of telegraph pole, 100 feet south of private road; iron post	6, 305. 841
La Boca, 60 feet west of track, 20 feet east of road, 300 feet north of water tank; iron post	6, 171. 719
La Boca, in front of station; top of rail	6, 167. 5
Ignacio, in front of station; top of rail	6, 431. 2
Ignacio, 4.4 miles southeast of, 50 feet west of track, 100 feet east of road; iron post stamped "6252"	6, 258. 768
Ignacio, 200 feet east of station, 100 feet east of road; iron post	6, 427. 460
Ignacio, 2.3 miles northwest of, 50 feet northwest of road crossing, 30 feet south of track, 600 feet southeast of milepost 428; iron post	6, 529. 448
Ignacio, 7.2 miles northwest of, 100 feet southwest of road crossing, 40 feet south of track; iron post	6, 597. 022
Florida, 1.7 miles southeast of, 80 feet southwest of milepost 435, 60 feet southwest of track, 150 feet east of private road; iron post	6, 720. 528
Florida, 50 feet south of freight platform, 250 feet northwest of bridge near telegraph pole; iron post	6, 690. 170
Milepost 445, 75 feet east of, 50 feet east of track, 1,500 feet north of road; iron post	6, 779. 973

	Feet.
Durango, 6.3 miles southeast of, 20 feet south of road, 500 feet south of track, on side of hill; iron post	6,728.417
Bocea, in front of station; top of rail	6,698.1
Durango, about 3 miles south of, 150 feet southeast of east end of Florida road, wagon bridge over Las Animas River, 60 feet west of railroad, in top of large red bowlder; aluminum tablet (Reclamation Service bench mark No. 3)	6,416.176

Colorado-New Mexico line north along Denver & Rio Grande R. R. to point 3 miles south of Durango, thence east to point 6 miles east of Bayfield.

NOTE.—The elevations of the first five of the following bench marks may be 3 feet greater.

Colorado-New Mexico line, 0.3 mile northwest of, in State of Colorado, 10 feet north of milepost "D 467"; iron post stamped "5936"	5,933.290
Colorado-New Mexico line, 4.2 miles north of, 0.1 mile south of milepost "D 463," opposite water tank, in line of telegraph pole; iron post stamped "5-6049"	6,046.223
Castelar, 1 mile south of post office, 30 feet west of road, on top of mesa; iron post stamped "6139"	6,136.079
Castelar, 3 miles north of, 30 feet west of road, on ridge; iron post stamped "B. M. 219 6210"	6,206.571
Castelar, 3.4 miles north of, sec. 36, T. 34 N., R. 10 W., 30 feet west of wagon road above and 150 feet west of house of Weaselskin (a Ute Indian), on right bank of Animas River, in top of buried granite bowlder 3 by 4 feet, about 2 feet above ground; aluminum tablet stamped "6202" (Reclamation Service bench mark No. 4; its elevation 6,199.798 feet)	6,206.218

NOTE.—A break of 8 feet is made in the computed line here on account of circuit closure and the closure on this and a following Reclamation Service bench mark.

Castelar, 6.2 miles north of, 20 feet west of road, on top of mesa; iron post stamped "6344 B. M. 223"	6,344.319
Bocea, 0.5 mile southeast of station, 20 feet south of road, 50 feet south of railroad track, on side of hill; iron post stamped "6723 B. M. 230"	6,728.317
Bocea, 2.5 miles east by 0.5 mile north of, road forks at northeast corner of B. Bellino's field; iron post stamped "6993 B. M. 233"	6,992.275
Bocea, 4.5 miles east by 1.25 miles north of, 1 mile east of Florida River, 50 feet north of road, near lone pinion tree; iron post stamped "6917 B. M. 225"	6,917.498
Bayfield, 6.5 miles northwest of, 20 feet south of road, on top of ridge; iron post stamped "7071 B. M. 238"	7,071.639
Bayfield, 3 miles southwest of, 25 feet north of road, 60 feet west of large pressure pipe; iron post stamped "6855 B. M. 242"	6,854.754
Bayfield, 0.5 mile west of, in road forks of Durango and Ignacio road, on west side of Pine River; iron post stamped "6913 B. M. 245"	6,913.426
Bayfield, 2.8 miles east of, 20 feet west of road, on top of ridge 600 feet east of deserted mill; iron post stamped "6940 B. M. 249"	6,950.839
Bayfield, 5.9 miles east of, 20 feet west of road, 30 feet south of arroyo; iron post stamped "7224 B. M. 252"	7,225.169

Bayfield south down Pine River to State line.

	Feet.
Bayfield, 3.5 miles south of, 15 feet west of road, in line with cedar bush; iron post	6, 789. 303
Ignacio agency, at west end of highway bridge, old Geological Survey iron post stamped "6469 B. M. 326"	6, 478. 447

PAGOSA SPRINGS QUADRANGLE.

Graham's ranch northeast 3 miles.

Graham's ranch, 3 miles northeast of, beside wire fence, 10 feet east of gate through which trail passes, in top of granite bowlder; bronze tablet stamped "7873 DUR"	7, 879. 156

At Thomas & Spaeth's store.

Thomas & Spaeth's store, southeast corner of, 160 feet north of track; iron post	6, 221. 171

State line crossing near milepost 384 west along Denver & Rio Grande R. R. to milepost 410.

Juanita, 150 feet southeast of post office and freight platform, 60 feet north of track, 150 feet south of Navajo River; iron post	6, 327. 606
Pagosa Junction, southwest fence corner of W. Zabriski's store, 150 feet north of track, 200 feet northwest of station; iron post	6, 266. 048
Milepost 392, 75 feet east of, 40 feet north of road crossing, 200 feet north of San Juanita River, in sandstone bowlder; aluminum tablet	6, 231. 805
Carracas, 90 feet south of signboard, 10 feet west of northwest corner of section house; iron post	6, 166. 213
Milepost 397, 300 feet northwest of, 50 feet north of track, 30 feet south of road and wire gate, in fence corner; iron post	6, 127. 621
Milepost 399, 15 feet south of, 50 feet north of track, 75 feet south of road; iron post	6, 094. 745
Arboles, northwest corner of B. A. Rodriguez store and post office, 100 feet south of track; iron post	6, 004. 384
Arboles, in front of station; top of rail	6, 007
Milepost 406, 150 feet northwest of, 70 feet northeast of road crossing; iron post	6, 124. 600
Milepost 409, 0.7 mile east of, 50 feet southwest of road crossing, 20 feet west of irrigating ditch, 40 feet south of track; iron post	6, 169. 036

Point 6 miles east of Bayfield east along road to dike.

Lange ranch, 300 feet east of ranch house, in road forks; iron post stamped "7333 B 255"	7, 332. 670
Mack ranch, 2.3 miles east of, top of Yellow Jacket divide, 10 feet west of road; iron post stamped "7900 B. M. 258"	7, 899. 822
Piedra, Charles Freeman's ranch, 15 feet north of road, on top of small ridge; iron post stamped "7024 B. M. 262"	7, 021. 044
Campbell's ranch, 0.4 mile south of, 20 feet east of road; iron post stamped "6670 B. M. 265"	6, 669. 257
Harland's ranch, forks of Bayfield-Pagosa Springs and Bayfield-Arboles roads; iron post stamped "6450 B. M. 268"	6, 448. 966

	Feet.
Harland's ranch, 2.8 miles southeast of, 15 feet east of road, on Devil Hill; iron post stamped "6751 B. M. 271"	6, 749. 7
Harland's ranch, 6.3 miles southeast of, 15 feet west of road, on top of ridge; iron post stamped "6794 B. M. 274"	6, 793. 12

Dike east along Denver & Rio Grande R. R. to Pagosa Springs.

Dike, opposite signboard; top of rail	6, 807. 6
Dike, 600 feet east of post office, 12 feet north of road, 40 feet south of track; iron post stamped "6801 B. M. 277"	6, 800. 68
Dike, 3.5 miles northeast of, 50 feet north of milepost "D 411," 60 feet south of road; iron post stamped "7020 B. M. 280"	7, 020. 095
Nutria, in front of signboard; top of rail	7, 043. 7
Hatcher spur, 0.5 mile north of, 30 feet east of milepost "D 414"; iron post stamped "7379 B. M. 283"	7, 378. 519
Sumetha, in front of signboard; top of rail	7, 508. 0
Sumetha, 1.2 miles northeast of, 60 feet north of track, 20 feet east of road; iron post stamped "7463 B. M. 287"	7, 463. 119
Pagosa Springs, south end of station platform, in line with front of station; iron post stamped "7104 B. M. 290"	7, 103. 522
Pagosa Springs, in base of watering trough; aluminum tablet stamped "7079 B. M. 291"	7, 078. 954

Point 3 miles northeast of Vallecito northeast along Pine River to junction with trail northwest to Emerald Lake.

Graham's ranch, 6 miles northeast of, 30 feet north of trail, about 0.2 mile northeast of Pine River crossing, in top of flat triangular-shaped bowlder; bronze tablet stamped "7985 DUR"	7, 991. 443
Graham's ranch, 8.5 miles northeast of, 17 feet northwest of forks at junction with trail running northwest to Emerald Lakes, 0.1 mile northwest of Lake Fork, in top of granite bowlder; aluminum tablet stamped "8185 DUR"	8, 191. 582

CHROMO QUADRANGLE.

Pagosa Springs southeast along road to Edith.

Pagosa Springs, 4.1 miles southeast of, 15 feet east of road, on top of ridge; iron post stamped "7248 B. M. 296"	7, 244. 812
Pagosa Springs, 8 miles south of, 15 feet north of road, on top of Eightmile Hill, 30 feet east of road forks, in top of a 4-inch iron pipe buried in ground; aluminum tablet stamped "7521 B. M. 300"	7, 517. 868
Halfway House, 0.2 mile east of, 15 feet east of road, near burnt pine stump, in top of sandstone bowlder; aluminum tablet stamped "7135 B. M. 304"	7, 132. 858
Halfway House, 3.6 miles east of, on top of divide 15 feet south of road, 50 feet east of track, in top of sandstone post; aluminum tablet stamped "7758 B. M. 307"	7, 753. 995
Halfway House, 8 miles south of, 15 feet east of road, on top of ridge, in top of sandstone post; aluminum tablet stamped "7402 B. M. 311"	7, 398. 319

Durango, La Plata, Lewis Creek, and Mancos 15′ quadrangles and Cortez and Ignacio 30′ quadrangles.

LA PLATA AND MONTEZUMA COUNTIES.

The elevations in the following list are based on heights of bench marks at Durango.

The leveling was done in 1910 by M. R. McDanal.

DURANGO QUADRANGLE.

Durango west along Rio Grande Southern R. R. 2 miles (double-rodded line).

	Feet.
Durango, near freight depot, west of railroad; iron pin in bowlder	6,516.19
Durango, 1 mile west of; iron pins in cross tie on trestle over Lightner Creek	6,522.46 6,522.44
Durango, 1.7 miles west of, near road crossing at brickkiln; iron pins in bridge over Lightner Creek	6,595.52 6,595.45
Durango, 2.1 miles west of; spike in base of milepost 160	6,659.46

IGNACIO 30′ QUADRANGLE.

Point 4 miles west of Durango along Rio Grande Southern R. R. to point 3 miles west of Porter.

	Feet.
Durango, 4 miles west of, on south side of railroad; cross marks in bowlder	6,943.28 6,943.26
Porter, 2 miles east of, south side of wagon road, 4 feet from southwest corner of frame shack, 12 feet above road, in sandstone ledge; aluminum tablet stamped "6980"	6,977.128
Porter, 1 mile west of; nail in north side of milepost 156	7,129.38
Porter, 2 miles west of; spike in base of milepost 155	7,191.04
Porter, 3.3 miles west of, on small divide, north side of highway; bolt in top of stump	7,382.66 7,382.63

LA PLATA QUADRANGLE.

Point 3 miles west of Porter northwest along railroad to Menefee (double-rodded line).

	Feet.
Porter, 5.5 miles west of, northeast side of crossing of railroad and highway; cross in top of bowlder	8,003.93 8,003.91
Ute Junction, 0.1 mile east of, at north end of Y; bolts in base of switch block	8,100.51 8,100.57
Hesperus, south end of siding, at tool house; bolts in base of switch block	8,116.67 8,116.71
Hesperus, 50 feet west of station, 6 feet below level of track, in granite bowlder; aluminum tablet stamped "8113"	8,110.978
Hesperus, 1.1 miles west of, on north side of track; cross marks on top of bowlder	8,240.87 8,241.23
Hesperus, 1.4 miles west of; spikes in north side of base of milepost 144	8,289.39 8,289.34
Hesperus, 2.4 miles west of; spikes in north side of base of milepost 143	8,412.72 8,412.67
Hesperus, 3.5 miles west of, at branch road to north; spike in base of switch block	8,556.93
Hesperus, 3.8 miles west of, top of divide, 50 feet south of railroad, in sandstone bowlder; aluminum tablet stamped "8585"	8,582.310

	Feet.
Cima, west end of siding; spike in base of switch block	8,581.13
Cima, 1.3 miles west of; spikes in north side of base of milepost 140	8,563.02 8,562.81
Cima, 2.3 miles west of; spike in north side of base of milepost 139	8,443.94
Cima, 3.3 miles west of; spikes in base of milepost 138	8,324.97 8,324.90
Cima, 4.3 miles west of; spike in north side of base of milepost 137	8,253.70
Cima, 4.8 miles west of, east end of siding at Dix; spikes in base of switch block	8,217.42 8,217.54
Dix, 20 feet south of main track, midway between switch block at west end of siding and derail switch block, 330 feet west of station sign, in sandstone bowlder; aluminum tablet stamped "8209"	8,206.668
Dix, 0.4 mile west of; spikes in north side of base of milepost 136	8,188.26 8,187.98
Dix, 1.4 miles west of; spikes in base of north side of milepost 135	8,157.58 8,157.43
Dix, 2.4 miles west of; spikes in north side of base of milepost 134	8,139.88 8,139.70
Grady, at east end of siding; spike in base of milepost 133	8,132.58
Grady, 1.7 miles south of, on divide between Mancos River and Cherry Creek, 25 feet south of wagon road, 200 feet south of frame shack, 25 feet north of blazed pine tree, in sandstone bowlder; aluminum tablet stamped "7956"	7,953.510
Menefee, 0.3 mile west of, 520 feet east of milepost 125, 8 feet below and 10 feet north of railroad track, in sandstone bowlder; aluminum tablet stamped "7263"	7,260.516

MANCOS QUADRANGLE.

Menefee southwest along Rio Grande Southern R. R. to Mancos, thence southwest along highway to Point Lookout (double-rodded line).

Menefee, 1.5 miles west of; spikes in base of milepost 124	7,148.97
Menefee, 2.3 miles west of, at siding to south; bolt in base of switch block	7,080.03
Mancos, intersection of Main Street and Grand Avenue, southwest corner of First National Bank building, in third course of masonry; aluminum tablet stamped "7035"	7,032.588
Mancos, 0.9 mile west of, in fence around McGrew's residence; spike in base of gate post	6,964.49
Mancos, 2.7 miles west of, on south side of road 250 feet east of yellow house north side of road; spike in base of gate post	6,871.64
Mancos, 3.1 miles west of, at T road south; spike in base of fence post	6,788.61
Mud Creek, 0.1 mile east of, top of hill at sharp bend in road, north side of road; spike in fence post	6,694.50
Mud Creek, 60 feet east of bridge, on fence line, north side of road, in granite bowlder; aluminum tablet stamped "6631"	6,628.414
Mud Creek, 1.1 miles west of, 200 feet north of road; spike in base of telegraph pole	6,683.51
Mud Creek, 1.5 miles west of; spike in east end of truss of bridge over dry arroyo	6,716.50
Government Cabin, 40 feet southwest of, at entrance to Mesa Verde National Park, in sandstone bowlder; aluminum tablet stamped "7239"	7,236.402

	Feet.
Government Cabin, 0.3 mile south of, divide between Mancos and Dolores rivers, just north of road at edge of park boundary; spike in base of cedar tree	7, 457. 45
Lookout triangulation station, Mesa Verde Park, in sandstone bowlder at base of pinyon tree used as signal; aluminum tablet stamped "8431"	8, 428. 451

Point Lookout south along trail to point 3.5 miles south of Morfield Canyon (single-rodded line).

Morfield Canyon, 0.9 mile from head of, 25 feet northeast of trail; top of sandstone bowlder	7. 742. 40
Morfield Canyon, 2.2 miles from head of, quarter corner 150 feet west of large bowlder, 150 feet east of blazed pine tree; top of stone	7, 529. 98
Morfield Canyon, 2.3 miles from head of, cabin, 200 feet south of, 700 feet north of windmill, in sandstone bowlder; aluminum tablet stamped "7510"	7, 507. 123
Morfield Canyon, 2.4 miles from head of, in base of foundation of windmill; spike	7. 483. 00

East Gap at head of Morfield Canyon to West Fork Canyon (single-rodded line).

Divide between Prater and Moccasin canyons, 25 feet south of trail; nail in root of lone pine tree	8, 325. 44
Divide between Moccasin Canyon and east fork of School Section Canyon, south side of trail; top of sandstone bowlder	8, 357. 51
School Section Canyon, head of east fork, on north side of trail; top of sandstone bowlder	8, 231. 59
School Section Canyon, ridge between east and west forks of, on north side of trail; top of sandstone bowlder	8, 346. 314
School Section Canyon, head of west fork, 25 feet north of trail, 50 feet south of rim rock, in northeast corner of sandstone bowlder; aluminum tablet stamped "8155"	8, 152. 351

Park south along trail 2 miles (single-rodded line).

Park, triangulation station, in base of sandstone bowlder; aluminum tablet	8, 571. 51
Park, 0.4 mile south of, on ridge, east side of trail; top of sandstone bowlder	8, 420. 49
Park, 1.7 miles south of, on ridge, in old ruins on west side of trail; top of sandstone bowlder	8, 086. 56
Park, 2.1 miles south of, on ridge, at bend, on southeast side of trail; top of sandstone bowlder	7, 982. 87

Head of Soda Canyon west to ridge between west prong of East Fork and east prong of West Fork of Little Soda Canyon (single-rodded line).

Soda Canyon, head of, in trail 300 feet west of drain; top of sandstone bowlder	8, 154. 67
Soda Canyon and prong of east fork of Little Soda Canyon, on head of ridge between, old trail; top of sandstone bowlder	8, 398. 99
Little Soda Canyon, head of ridge between east and west prongs of east fork of, on north side of trail; top of sandstone bowlder	8, 308. 32

	Feet.
Little Soda Canyon, ridge between west prong of east fork and east prong of west fork of, on north side of trail; top of sandstone bowlder	8, 302. 48

LEWIS CREEK QUADRANGLE.

Point 4.5 miles south of head of Morfield Canyon south 1.3 miles (single-rodded line).

T. 35 N., R. 14 W., 500 feet southwest of corner between secs. 32 and 33, 5.8 miles from head of Morfield Canyon, in sandstone bowlder in part of old ruins; aluminum tablet stamped "7220"	7, 217. 226

Point 2.7 miles south of Park south 0.3 miles.

Park, 2.7 miles south of, on ridge, east side of trail, in sandstone bowlder; aluminum tablet stamped "7895"	7, 892. 529
Park, 3 miles south of, on ridge, east side of intersection of trails; top of sandstone bowlder	7, 811. 24

Milepost 76.5 on Ute Reservation line to head of Spruce Tree Canyon.

Milepost 76.5, on Ute Reservation line, east side of road, in top of; spike	7, 357. 04
Spruce Tree Canyon, head of, 25 feet southeast of reservoir, 200 feet north of Spruce Tree House, in rim rock; aluminum tablet stamped "6932"	6, 929. 668

CORTEZ 30′ QUADRANGLE.

East prong of West Fork of Little Soda Canyon south along trail to point 4 miles north of head of Spruce Tree Canyon (single-rodded line).

Little Soda Canyon, head of east prong of west fork of, 200 feet north of old trail, 300 feet east of Kelly's trail; top of sandstone bowlder	8, 122. 35
Little Soda Canyon, summit and head of ridge between north prong of west fork of, and east fork of Navajo Canyon, 10 feet south of bluff, in sandstone bowlder; aluminum tablet stamped "8338"	8, 335. 538
Little Soda Canyon, 1,200 feet south of head of north prong of west fork of, on east side of Kelly's trail; top of sandstone bowlder	7, 994. 93
Rim of mesa, 3.2 miles south of, 15 feet west of road, in sandstone bowlder by pile of rocks; aluminum tablet stamped "7639"	7, 636. 946

East Fork of Navajo Canyon southwest along highway and trail to Pinyon (single-rodded line).

Navajo Canyon, head of east fork of, 25 feet west of drain, 10 feet south of bluff; top of sandstone bowlder	8, 096. 34
Long Canyon, summit of ridge between first and second prongs of, 300 feet south of bluff, 10 feet north of old trail, in bowlder; aluminum tablet stamped "8300"	8, 297. 570
Pinyon triangulation station, 10 feet east of bluff, in sandstone bowlder at base of trimmed pinyon tree; aluminum tablet stamped "8310"	8, 307. 318

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 487

RESULTS OF SPIRIT LEVELING IN IDAHO

1896 TO 1909, INCLUSIVE

R. B. MARSHALL, CHIEF GEOGRAPHER

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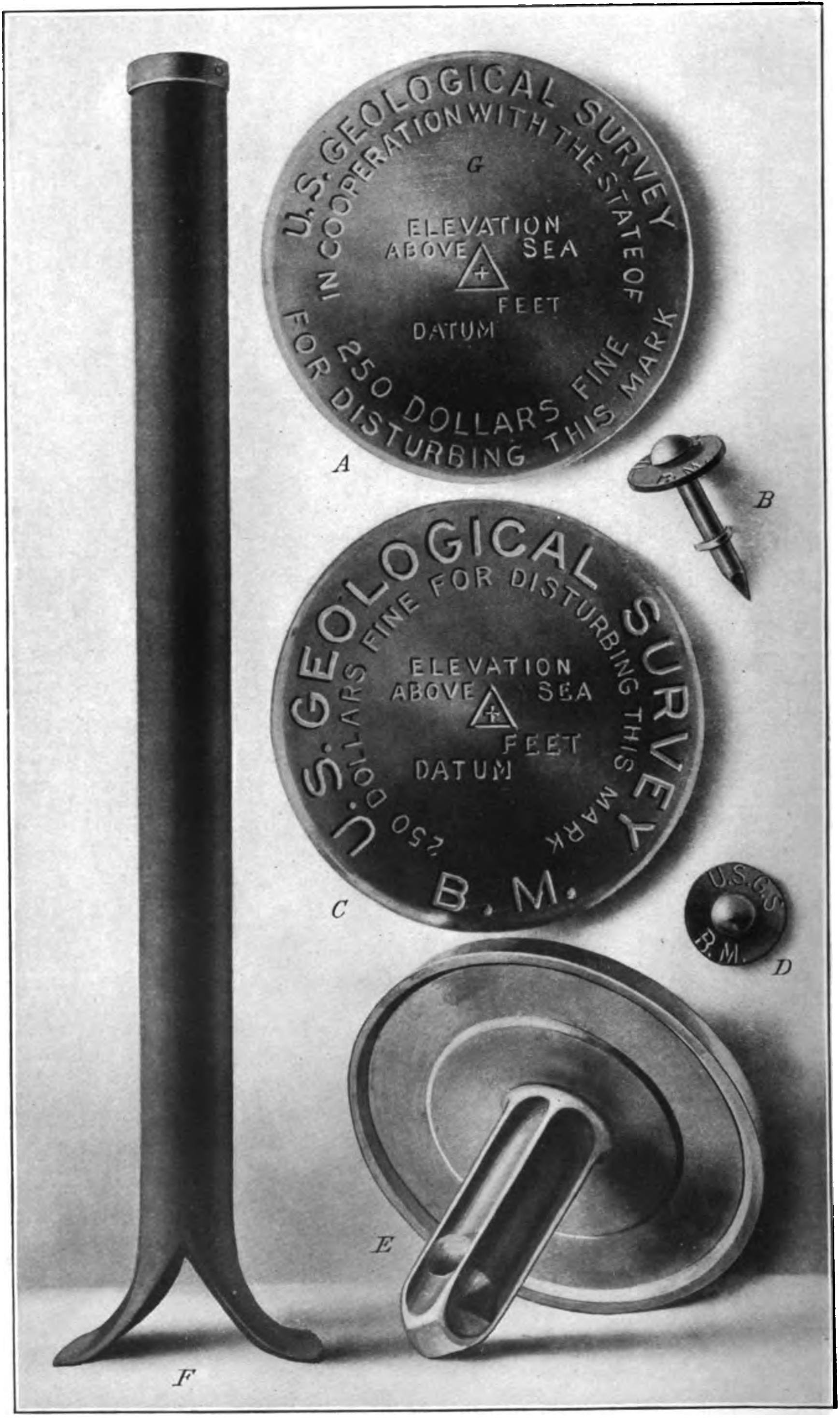

GEOLOGICAL SURVEY BENCH MARKS.

A, Tablet used in cooperating States. The State name is inserted at *G*.
B and *D*. Copper temporary bench mark, consisting of a nail and copper washer.
A, *C*, and *E*. Tablets for stone or concrete structures.
F, Iron post used where there is no rock.

RESULTS OF SPIRIT LEVELING IN IDAHO, 1896 TO 1909, INCLUSIVE.

R. B. Marshall, Chief Geographer.

INTRODUCTION.

Scope of the work.—All results of spirit leveling in Idaho previously published by the United States Geological Survey and all results of later work in the State are included in this report, rearranged by quadrangles. Most of the elevations are based on the precise-level line of the United States Coast and Geodetic Survey from Seattle, Wash., via Pocatello, Idaho, to Evanston, Wyo., from the preliminary adjustment by that bureau in 1911.

Personnel.—The field work previous to 1903 was done under the general direction of R. U. Goode, geographer; that for 1903 to 1906, inclusive, under E. M. Douglas, geographer; that for 1907 under R. B. Marshall, geographer; and the later work under T. G. Gerdine, geographer, under the general direction of R. B. Marshall, chief geographer. Credit is given to the different levelmen in the introduction to each list. The office work of computation, adjustment, and preparation of lists was done mainly by S. S. Gannett, geographer, and D. H. Baldwin, topographer, and since 1907 under the general direction of E. M. Douglas, geographer.

Classification.—The elevations are classified as precise or primary, according to the methods employed in their determination. For precise lines instruments and rods of the highest grade are used, each line is run in both forward and backward directions, and every precaution is taken to guard against error. The allowable divergence between the forward and the backward lines in feet is represented by the formula $0.017\sqrt{D}$, in which D is the distance in miles between bench marks. For primary lines standard Y levels are used; lines are run in circuits or are closed on precise lines, with an allowable closing error in feet represented by the formula $0.05\sqrt{D}$, in which D is the length of the circuit in miles, sufficient care being given the work to maintain this standard. For levels of both classes careful office adjustments are made, the small outstanding errors being distributed over the lines.

Bench marks.—The standard bench marks are of two forms. The first form is a circular bronze or aluminum tablet (*C* and *E*, Pl. I), 3½ inches in diameter and one-fourth inch thick, having a 3-inch stem, which is cemented in a drill hole in solid rock, in the wall of some public building, in a bridge abutment, or in other substantial masonry structure. The second form (*F*, Pl. I), employed where masonry or rock is not accessible, consists of a hollow wrought-iron post 3½ inches in outer diameter and 4 feet in length after being split at the bottom and expanded to 10 inches in order to give a firm bearing on the earth. A bronze or aluminum-bronze cap is riveted over the top of the post, which is set about 3 feet in the ground. A third style of bench mark with abbreviated lettering (*B* and *D*, Pl. I) is used for unimportant points. This consists of a special copper nail 1½ inches in length driven through a copper washer seven-eighths of an inch in diameter.

The tablets, as well as the caps on the iron posts, are appropriately lettered, and for cooperating States the fact of such cooperation is indicated by the addition of the State name (*G*, Pl. I). The numbers stamped on the bench marks described in the following pages represent the elevations to the nearest foot as determined by the levelman. These numbers are stamped with $\frac{3}{16}$-inch steel dies on the tablets or post caps, to the left of the word "feet." The office adjustment of the notes and the reduction to mean sea-level datum may so change some of the figures that the original markings are 1 or 2 feet in error. It is assumed that engineers and others who have occasion to use the bench-mark elevations will apply to the Director of the United States Geological Survey, at Washington, D. C., for the adjusted values, and will use the markings as identification numbers only.

Datum.—All United States Geological Survey elevations are referred to mean sea level, which is the level that the sea would assume if the influence of winds and tides were eliminated. This level is not the elevation determined from the mean of the highest and the lowest tides, nor is it the half sum of the mean of all the high tides and of the mean of all the low tides, which is called half-tide level. *Mean sea level is the average height of the water, all stages of the tide being considered.* It is determined from observations made by means of tidal gages placed at stations where local conditions, such as long, narrow bays, rivers, and like features, will not affect the height of the water. To obtain even approximately correct results these observations must extend over at least one lunar month, and if great accuracy is desired they must extend over several years. At ocean stations half-tide level and mean sea level usually differ but little. It is assumed that there is no difference between the mean sea level as determined from observations in the Atlantic Ocean, the Gulf of Mexico, or the Pacific Ocean.

The connection with tidal stations for bench marks in certain areas that lie at some distance from the sea coast is still uncertain, and this fact is indicated by the addition of a letter or a word to the right of the word "Datum" on tablets or posts. For such areas corrections of published results will be made from time to time as the precise-level lines of the United States Geological Survey or other Government organizations are extended.

Topographic maps.—Maps of the following quadrangles wholly or partly in Idaho have been published by the United States Geological Survey up to August 1, 1911. They may be obtained, except as noted, for 5 cents each or $3 a hundred, on application to the Director of the Survey at Washington, D. C.

Bear Valley.
Bisuka.
Boise.
Camas Prairie.
Cœur d'Alene special (Idaho-Montana) (10 cents).
Garden Valley.
Hailey.
Hamilton (Montana-Idaho).
Idaho Basin.
Meadows.
Mitchell Butte (Oregon-Idaho).
Mountain Home.
Nampa (Idaho-Oregon).
Oakesdale (Washington-Idaho).
Pullman (Idaho-Washington).
Rathdrum.
Rocky Bar.
Sandpoint.
Sawtooth.
Silver City.
Spokane (Washington-Idaho).
Squaw Creek.
Weiser (Idaho-Oregon).

PRECISE. LEVELING.

Birch Creek and Weiser quadrangles.

CANYON AND WASHINGTON COUNTIES.

The elevations in the following list are results of a line of precise leveling begun at Huntington, Oreg., and run southeast along the Oregon Short Line Railroad in Idaho to Ontario, Oreg. This line was redetermined by the Coast and Geodetic Survey, being part of its transcontinental line of precise leveling, and was corrected to accord with the heights obtained by the preliminary 1911 adjustment.

The double simultaneous method of leveling was employed, using a Van Orden type of precise level and special rods.

The leveling was done in 1903 by C. H. Semper.

For results along this line in Oregon see Bulletin 462.

BIRCH CREEK QUADRANGLE.

Point near Huntington, Oreg., south along Oregon Short Line Railroad to Eaton, Idaho.

	Feet.
Huntington, 5.2 miles east of, on north side of railroad, at first telegraph pole west of milepost 536, 8 feet from fence; iron post stamped "2069 H"	2,076.919
Huntington, 8.1 miles east of, between track and milepost 533, 18 feet east of track; iron post stamped "2070 H"	2,077.363
Old's Ferry, 2.2 miles east of, on north side of railroad, 70 feet west of seventh telegraph pole east of milepost 530, 10 feet north of track; iron post stamped "2086 H"	2,093.395

	Feet.
Old's Ferry, 5.2 miles east of, on north side of railroad, 15 feet east of fifth telegraph pole east of milepost 527, 10 feet north of track; iron post stamped "2087 H"	2,094.325
Eaton, at road crossing; top of rail	2,104.0
Eaton, 0.3 mile southeast of, at mile post 524, on west side of track, at fence line; iron post stamped "2097 H"	2,104.291

WEISER QUADRANGLE.

Eaton along Oregon Short Line Railroad to point 2.2 miles south of Payette.

Eaton, 3.2 miles southeast of, first telegraph pole west of milepost 521, at fence line; iron post stamped "2122 H"	2,129.792
Weiser, 13.6 feet west of new station, 41.3 feet north of track, just inside of park, on fence line; iron post stamped "2107 H"	2,115.833
Weiser, in front of station; top of rail	2,113.8
Weiser, 3.3 miles south of, 4 feet north of milepost 515, west of track; iron post stamped "2113 H"	2,120.494
Weiser, 6.3 miles south of, first telegraph pole south of milepost 512, at fence line, west of track; iron post stamped "2112 H"	2,119.775
Crystal, in front of station sign; top of rail	2,122.9
Crystal, 2.6 miles south of, west of track, first telegraph pole north of milepost 509, at fence line; iron post stamped "2123 H"	2,130.752
Payette, 0.9 mile north of, west of track, at fence line, 27 feet south of milepost 506; iron post stamped "2139 H"	2,146.328
Payette, in front of station; top of rail	2,147.2
Payette, 2.2 miles south of, 285 feet south of milepost 503, 10 feet east of track; iron post stamped "2139 H"	2,147.104

PRIMARY LEVELING.

Cambridge, Meadows, Squaw Creek, and Weiser quadrangles.

BOISE AND WASHINGTON COUNTIES.

The elevations in the following list are based on the preliminary 1911 adjusted elevation of Bench Mark G_6 of the Coast and Geodetic Survey at Weiser, Idaho, on the transcontinental line of precise levels.

The leveling in the Squaw Creek quadrangle was done by D. A. Maxwell in 1907, and that in the other quadrangles by Maxwell and J. G. Hefty in the same year. A check line was run in the Weiser quadrangle in 1908 by W. B. Jones.

WEISER QUADRANGLE.

Weiser along Pacific & Idaho Northern Railway east 11.7 miles (checked line), thence north to Midvale (mean of direct and reverse lines).

	Feet.
Weiser, in west wall of brick building occupied by the Masonic Lodge, 9.84 feet (3 meters) north of the southwest corner and 3.94 feet (1.2 meters) above ground; copper bolt leaded in wall, stamped "U. S. B. M." (Coast and Geodetic Survey B. M. G_6). The Coast and Geodetic Survey description gave this location incorrectly as the northwest corner	2,121.516
Weiser, in west wall of brick courthouse at Oldtown, about 1 mile east of railroad station; red metal disk lettered "Coast and Geodetic Survey B. M. H_6," set flush with surface	[1] 2,118.520

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[1] The corner of building is cracked from settling, just above the bench mark. The Coast and Geodetic Survey elevation of 2,118.234 feet was therefore not accepted.

	Feet.
Weiser, 2 miles east of, 10 feet south of track, in foot of milepost 2; spike head flush with ground	2,117.79
Weiser, 3.8 miles east of, 50 feet north of track, at edge of right of way, opposite milepost 4; iron post stamped "2136 W"	2,136.487
Weiser, 5 miles east of, south side of track, in foot of milepost 5; spike	2,148.81
Weiser, 5.8 miles east of, south side of track, in foot of milepost 6; spike	2,159.09
Weiser, 6.8 miles east of, 50 feet north of track, at edge of right of way, opposite milepost 7, 30 feet east of wagon road crossing railroad at right angles, about 300 feet north of large yellow house; iron post stamped "2167 W"	2,167.278
Weiser, 9.8 miles east of, 50 feet north of track, opposite milepost 10, at mouth of Weiser River Canyon, 1,000 feet southeast of unused smelter, in outcropping bowlder; aluminum tablet stamped "2210 W"	2,210.517
Weiser, 10.8 miles east of, 10 feet south of track, in foot of milepost 11; spike	2,215.92
Weiser, 12.9 miles northeast of, 9 feet west of track, 165 feet north of milepost 13, at foot of low retaining wall along upper side of grade, 100 feet from river, in top of large flat basalt bowlder on east side of rocky bluff, 1,800 feet south of mouth of large stream from east; aluminum tablet stamped "2249 W"	2,250.256
Weiser, 15.9 miles northeast of, opposite milepost 16, 40 feet south of track, near mound of rocks, in large basaltic bowlder; aluminum tablet stamped "2275 W"	2,275.217
Weiser, 19 miles northeast of, 600 feet north of milepost 19, north side of dry gulch, 50 feet west of track, on point of knoll, in volcanic bowlder alongside mound of rocks; aluminum tablet stamped "2338 W"	2,338.450
Midvale, 9.5 miles south of, 270 feet north of milepost 22, near mouth of Thousand Spring Creek, 10 feet west of track, in large volcanic bowlder; aluminum tablet stamped "2373 W"	2,373.131
Midvale, 8.5 miles south of, east side of track, in foot of milepost 23; spike	2,388.26
Midvale, 6.5 miles south of, at sharp curve in track, 18 feet northeast of milepost 25, 24 feet east of track, between track and river, near mound of rocks, in top of large bowlder; aluminum tablet stamped "2454 W"	2,454.751
Midvale, 4.5 miles south of, east side of track, in base of milepost 27; spike	2,501.66
Diamond Springs, in front of section house; top of rail	2,506.9
Midvale, 3.5 miles south of, 85 feet north of milepost 28, 14 feet east of track, beside a cairn of rock, top of volcanic bowlder; aluminum tablet stamped "2514 W"	2,514.811
Midvale, 1. 5 miles south of, 45 feet west of track, in base of telegraph pole (milepost 30); spike	2,528.32
Midvale, 0.5 mile south of, 45 feet west of track, in foot of telegraph pole (milepost 31); spike	2,533.11
Midvale, cement block building occupied by Bank of Washington County, at outer entrance, on south side and inner face of entrance, about 4.5 feet above floor; aluminum tablet stamped "2544 W"	2,544.643

Midvale east along road to J. R. McMahan's ranch.

Midvale, 3.5 miles east of, on Midvale-Indian Valley road, 1,000 feet east of Richard Gaber's ranch house, 80 feet south of road and 40 feet south of wire fence in field, in volcanic bowlder, near mound of rock; aluminum tablet stamped "2724 W"	2,726.181
Midvale, 7 miles east of, on Indian Valley-Midvale road, 10 feet south of road, in base of fencepost; 30-penny nail, aluminum tag	3,210.91

	Feet.
T. 13 N., R. 2 W., sec. 21, 10.7 miles west of Indian Valley-Midvale crossroads 1,000 feet east of ranch, 40 feet south of road, mound of rocks in top of volcanic bowlder; aluminum tablet stamped "3292" W"	3,293,930
T. 13 N., R. 2 W., secs. 23 and 24, 7.2 miles west of Indian Valley-Midvale crossroads, 40 feet south of county road, at J. R. McMahan's ranch, 200 feet north of house, in volcanic bowlder; aluminum tablet stamped "3245 W"	3,246.789

CAMBRIDGE QUADRANGLE.

Midvale northeast along Pacific & Idaho Northern Railway to milepost 56.

Midvale, 3.2 miles north of, 9 feet north of telegraph milepost 35, 40 feet west of tract, 10 feet above and 40 feet north of small creek; iron post stamped "2587 W"	2,587.267
Midvale, 4.2 miles north of, 25 feet southwest of milepost 36, 75 feet west of tract; point on large bowlder	2,590.46
Trestle 30, northeast corner; bolt head marked with chiseled cross (+)	2,596.82
Midvale, 6.2 miles north of, 80 feet north of milepost 38, west side of track, in face of large volcanic bowlder; aluminum tablet stamped "2620 W"	2,620.783
Midvale, 7.2 miles north of, 140 feet west of trestle 32, 450 feet south of milepost 39, on slope of rock; chisel mark on rock	2,623.35
Cambridge, 70 feet north of station, at edge of right of way, corner of lot on south side of central boulevard, at edge of sidewalk; iron post stamped "2651 W"	2,651.347
Cambridge, 3.8 miles north of, 1,800 feet north of milepost 44, at short rock cut near end of long low spur from main ridge to west, 20 feet west of track, top of bank 8 feet above level of track, in outcropping rock; aluminum tablet stamped "2700 W"	2,699.919
Cambridge, 6.5 miles north of, 600 feet north of trestle 42 across small creek, at point of hill, 10 feet west of track, in cap of box culvert; drift bolt marked with chiseled cross	2,718.35
Cambridge, 7.5 miles north of, 1.5 miles south of Goodrich Creek, 120 feet east of telegraph pole marked "48 miles," 40 feet west of track, on volcanic bowlder 2.5 by 2.5 by 1 foot, near mound of rocks; aluminum tablet stamped "2736 W"	2,735.997
Cambridge, 8.5 miles north of, 150 feet south of milepost 49, 70 feet east of track in root of lone leaning cottonwood tree in field; nail	2,736.31
Council, 8.5 miles south of, 100 feet south of railroad bridge 47 across Weiser River, 20 feet west of track, in cement at surface of ground; aluminum tablet stamped "2782 W"	2,782.399
Council, 5.5 miles south of, 300 feet south of road crossing, 100 feet west of track; point on large bowlder	2,819.25
Council, 5 miles south of, 20 feet west of milepost 55, 8 feet south of track, 100 feet west of trestle 49, in face of solid rock wall 20 feet high, 5 feet above ground, in cement wall flush with surface; aluminum tablet stamped "2860 W"	2,859.926

Bench marks established along Indian Valley-Van Wyck road, near Van Wyck.

T. 14 N., R. 2 E., in sec. 25, on Indian Valley road, Lookout Mountain, in volcanic bowlder; aluminum tablet stamped "7811 W"	7,812.485
Van Wyck, 7.8 miles west of, in saddle 10 feet south of Van Wyck and Indian Valley road, in pine tree; 30-penny nail	7,379.369
Van Wyck, 8.9 miles west of, on Van Wyck-Indian Valley road, 30 feet south of, in pine tree; 30-penny nail with aluminum tag	7,020.118
Van Wyck, 10.2 miles west of, on Van Wyck-Indian Valley road, 50 feet east of, in pine tree; nail	6,565.49

	Feet.
Van Wyck, 10.8 miles west of, near center of sec. 34, T. 14 N., R. 2 E., 30 feet north of Van Wyck-Indian Valley road, 150 feet south of Sheep Creek, in top of volcanic bowlder; aluminum tablet stamped "6210 W"	6, 211. 754

MEADOWS QUADRANGLE.

Milepost 56 north along Pacific & Idaho Northern Railway to triangulation station 2 miles north of Council.

Council, 4 miles south of, 10 feet east of track, in base of milepost 56; spike.	2, 916. 29
Council, 2.5 miles south of, sec. 27, T. 16 N., R. 1 W., county road crossing, just north of Cottonwood Creek, 25 feet east of track, east of crossing signpost; iron post stamped "2939 W"	2, 940. 200
Council, 300 feet southeast of station, at foot of and at north side of main street of town, in angle of sidewalk and cross walk; iron post stamped "2910 W"	2, 911. 164
Council, in front of station; top of rail	2, 913. 9

Triangulation station 2 miles north of Council east along road to crossroads in T. 17 N., R. 3 E., thence northwest along road to Meadows, thence southwest to point near Council.

Council, 2.8 miles north of, on line between secs. 34 and 35, T. 17 N., R. 1 W., intersection of Council-Meadows and Mill Creek roads, 300 feet northeast of ranch house, west edge of road near fence; iron post stamped "3015 W"	3, 015. 880
Council, 6.2 miles northeast of, 1,000 feet east of line between secs. 31 and 32, T. 17 N., R. 1 E., at August Baurer's sawmill, between house and sawmill, south side of road, 100 feet north of Mill Creek, in top of large bowlder; aluminum tablet stamped "4023 W"	4, 024. 064
Council, 7.8 miles east of, in fir tree 15 feet north of road; 20-penny spike	4, 855. 77
Council, 9.6 miles northeast of, near southwest corner of sec. 22, T. 17 N., R. 1 E., intersection of roads in saddle, 50 feet east of forks, 10 feet north of road, in volcanic bowlder; aluminum tablet stamped "5612 W"	5, 613. 351
Council, 10.1 miles northeast of, in base of pine tree 5 feet south of road; spike	5, 941. 18
Council, 10.3 miles northeast of, in base of fir tree 6 feet south of road; spike.	6, 036. 48
Council, 10.6 miles northeast of, NW. ¼ sec. 26, T. 17 N., R. 1 E., 50 feet east of road, on Miller Summit, at mound of rocks, in volcanic rock; aluminum tablet stamped "6208 W"	6, 208. 824
Mill Creek Summit, 0.6 mile east of, in base of fir tree 3 feet south of road; spike	6, 281. 45
Mill Creek Summit, 1.2 miles east of, in base of balsam tree 3 feet west of road; nail	6, 335. 57
Mill Creek Summit, 1.8 miles east of, in fir tree 10 feet west of road; spike	6, 306. 59
Mill Creek Summit, 3 miles northeast of, in balsam fir 10 feet south of road; 20-penny spike	6, 306. 69
Mill Creek Summit, 3.6 miles east of, near quarter corner between secs. 6 and 31, Tps. 16 and 17 N., R. 2 E., 100 feet southeast of road, 100 feet west of east fork of Weiser River, in top of granite bowlder; aluminum tablet stamped "6245 W"	6, 246. 098
Mill Creek Summit, 4.5 miles east of, in tamarack tree 15 feet west of road; nail	6, 265. 44
Mill Creek Summit, 5.4 miles northeast of, in pine tree 20 feet north of road; nail	6, 399. 06
Mill Creek Summit, 6.6 miles east of, in base of fir tree 5 feet northeast of road; nail	6, 527. 29

	Feet.
T. 17 N., R. 2 E., NW. ¼ sec. 27, 120 feet east of road, mound of rocks, in saddle, in volcanic rock; aluminum tablet stamped "6521 W"	6,522.635
Long Valley Summit, 0.9 mile east of, in fir tree 10 feet west of road; nail	5,976.98
Long Valley Summit, 1.4 miles east of, in fir tree 10 feet east of road; nail	5,534.749
Long Valley Summit, 2.4 miles east of, in fir tree 10 feet north of road; nail	5,006.399
Long Valley Summit, 3.9 miles east of, SW. ¼ sec. 19, T. 17 N., R. 3 E., junction of Long Valley and Mill Creek roads, northeast corner of James Hartsel's fence, 1,700 feet east of house, 175 feet west of Payette River, 1,320 feet northeast of section corner; iron post stamped "4837 W"	4,838.393
Long Valley Summit, 5.3 miles east of, corner of secs. 18, 19, 29, and 30, T. 17 N., R. 3 E., in base of southeast corner fence post, at crossroads; nail with aluminum tag	4,889.32
Long Valley Summit, 8.3 miles east of, sec. 22, T. 17 N., R. 3 E., 500 feet south of log house, 5 feet north of road, at southeast corner of fence; iron post stamped "4897 W"	4,898.520
Long Valley Summit, 12.2 miles northeast of, in sec. 33, T. 18 N., R. 3 E., 50 feet southeast of road, in Sam Shaw's field, about 1,200 feet north of Tom Yount's house, 1,600 feet east of Gabriel Maenpad's house, in top of granite bowlder; aluminum tablet stamped "5029 W"	5,030.273
Long Valley Summit, 14.2 miles northeast of, in base of pine tree 10 feet west of road; nail	5,093.13
Long Valley Summit, 14.9 miles northeast of, in pine tree 10 feet west of road; nail	5,073.85
Old Lardo, sec. 9, T. 18 N., R. 3 E., 16.4 miles northeast of Long Valley Summit, south end of Payette Lake, 500 feet south of McCall Hotel, 200 feet north of sawmill, 20 feet south of road, in top of volcanic bowlder, near mound of rocks; aluminum tablet stamped "5030 W"	5,030.771
Old Lardo, in front of McCall Hotel; high-water mark	4,990
Old Lardo; surface of water, Payette Lake, July 30, 1907	4,985.5
Lardo, 400 feet east of post office, in sec. 8, T. 18 N., R. 3 E., 17.5 miles northeast of Long Valley Summit, 100 feet south of Payette Lake, 50 feet south of Lardo-Roseberry road, in granite bowlder; aluminum tablet stamped "5001 W"	5,002.114
Lardo, 1 mile west of, on Lardo-Meadows stage road, in yellow pine tree 25 feet south of road; nail	5,050.41
Lardo, 2 miles west of, on Lardo-Meadows stage road, in pine tree 20 feet west of road; nail	5,180.76
Lardo, 2.5 miles west of, sec. 1, T. 18 N., R. 2 E., on Lardo-Meadows stage road, on Payette River and Salmon Creek divide, about 80 feet north of road, 20 feet above road, in top of granite bowlder; aluminum tablet stamped "5352 W"	5,352.766
Lardo, 3.7 miles west of, on Lardo-Meadows stage road, in black pine tree south of road; nail	5,104.89
Lardo, 4.8 miles west of, on Lardo-Meadows stage road, in pine tree east of road; nail	5,052.15
Lardo, 5.8 miles west of, near center of sec. 34, T. 19 N., R. 2 E., on Lardo-Meadows stage road, on Meadows Summit, in saddle 70 feet north of road, in top of granite bowlder; aluminum tablet stamped "5093 W"	5,093.695
Lardo, 6.4 miles west of, on Lardo-Meadows stage road, in fir tree east of road; nail	4,730.80
Lardo, 7 miles west of, on Lardo-Meadows stage road, in pine tree north of road; nail	4,354.61
Meadows, south side of main street of town, north edge of sidewalk, northeast corner of porch at Meadows Hotel; iron post stamped "3975 W"	3,976.185

	Feet.
Meadows, 3.3 miles west of, on line between secs. 14 and 23, T. 19 N., R. 1 E., on Council-Meadows stage road, 0.4 mile west of Little Salmon River, 100 feet north of road, 800 feet northeast of sawmill, in rock beside mound of rocks; aluminum tablet stamped "3964 W"	3,965.136
Meadows, 4.4 miles west of, in pine tree 10 feet south of Council-Meadows road; nail	4,030.62
Meadows, 5.4 miles west of, in pine tree north of Council-Meadows road; nail	4,020.16
Meadows, 6.9 miles west of, sec. 17, T. 19 N., R. 1 E., on Council-Meadows stage road, at north end of Price Valley, on summit between Little Salmon and Weiser rivers, 100 feet east of road, in top of volcanic rock near mound of rocks; aluminum tablet stamped "4186 W"	4,187.179
Meadows, 7.7 miles southwest of, in pine tree 15 feet west of Council-Meadows stage road; nail	4,143.94
Meadows, 9.9 miles southwest of, in pine tree 50 feet west of Council-Meadows stage road; nail	4,108.33
Meadows, 10.5 miles southwest of, in sec. 31, T. 19 N., R. 1 E., on Council-Meadows stage road, 1 mile south of Price Valley, 60 feet west of road, 50 feet north of small creek, at old sawmill site, in volcanic rock; aluminum tablet stamped "4089 W"	4,089.827
Meadows, 12.5 miles southwest of, in pine tree 60 feet west of Council-Meadows stage road; nail	3,945.95
Meadows, 13.8 miles southwest of, 100 feet east of railroad grade, 200 feet east of Weiser River, in fir tree; nail	3,972.05
Evergreen, at terminal of Pacific & Idaho Northern Railway, in north part of sec. 30, T. 18 N., R. 1 E., 150 east of track, 200 feet directly east of Record Commercial Co. store, in top of volcanic bowlder; aluminum tablet stamped "3704 W"	3,704.697
Evergreen, 4.8 miles southwest of, sec. 2, T. 18 N., R. 1 W., 600 feet north of old sawmill, 300 feet north of track, at brow of hill, 200 feet northwest of log house, in volcanic bowlder near mound of rocks; aluminum tablet stamped "3302 W"	3,302.880
Starkey (Hot Springs), in front of station; top of rail	3,165.8
Starkey (Hot Springs), sec. 34, T. 18 N., R. 1 W., 100 feet southeast of station, 80 feet south of track, in top of volcanic bowlder; aluminum tablet stamped "3172 W"	3,172.610
Starkey (Hot Springs), 3.3 miles south of, sec. 15, T. 17 N., R. 1 W., 200 feet west of milepost 66, 400 feet south of house, 100 feet west of railway cut, in top of volcanic bowlder near mound of rocks; aluminum tablet stamped "3065 W"	3,066.071

Crossroads in T. 17 N., R. 3 E., south along road via Roseberry to Van Wyck, thence west 11.7 miles.

T. 17 N., R. 3 E., on line between secs. 23 and 26, 2.6 miles southeast of Lake Fork bridge, on Roseberry-Lardo stage road, 50 feet southeast of bridge across irrigation ditch 40 feet south of road; iron post stamped "4905 W"	4,905.924
Roseberry, near corner of secs. 11, 12, 13, and 14, T. 16 N., R. 3 E., in schoolhouse yard opposite post office; iron post stamped "4871 W"	4,872.034
Tps. 15 and 16 N., R. 3 E., corner of secs. 1, 2, 35, and 36, on Roseberry-Van Wyck stage road, northwest corner of schoolhouse yard, 300 feet southeast of Mr. Moore's house, 360 feet west of log house, in granite bowlder; aluminum tablet stamped "4874 W"	4,875.462

	Feet.
Roseberry, 7.8 miles south of, near southwest corner of sec. 14, T. 15 N., R. 3 E., on Roseberry-Van Wyck stage road, 300 feet southwest of Joe Downing's house, 150 feet north of Dry Branch, 50 feet east of road, in volcanic bowlder; aluminum tablet stamped "4822 W"	4,823.066
Roseberry, 11.4 miles south of, on line between secs. 2 and 3, T. 14 N., R. 3 E., on Roseberry-Van Wyck stage road, 0.5 mile south of Newton Marler house, 60 feet southeast of road, at corner of fence, in granite bowlder; aluminum tablet stamped "4802 W"	4,802.900
Van Wyck, on Main Street, at northeast corner of C. B. Fisher's general store; iron post stamped "4777 W"	4,778.103
Van Wyck, 3.7 miles northwest of, near center of sec. 20, T. 14 N., R. 3 E., at road forks 100 feet west of sawmill road, 150 feet south of Van Wyck-Indian Valley road, near mound of rocks, in volcanic bowlder; aluminum tablet stamped "4910 W"	4,910.875
Van Wyck, 4.7 miles west of, in pine tree 10 feet north of Van Wyck-Indian Valley road; nail	5,724.41
Van Wyck, 5.8 miles west of, in pine tree 10 feet north of Van Wyck-Indian Valley road; nail	6,156.89
Van Wyck, 6.8 miles west of, 20 feet north of Van Wyck-Indian Valley road, in fir tree; nail	6,801.76

Van Wyck east 3.7 miles to Norris ranch.

Crawford, 1.8 miles east of Van Wyck, northeast corner of W. D. Patterson's yard, opposite post office, 100 feet from main street of town, in top of granite bowlder; aluminum tablet stamped "4759 W"	4,760.244
Crawford, 1.9 miles east of, on section line at northwest corner of NE. ¼ sec. 29, T. 14 N., R. 4 E., at Anna J. Norris's ranch, 50 feet south of road, 30 feet southeast of house, in granite bowlder; aluminum tablet stamped "4811 W"	4,812.608

North along Indian Valley, Midvale, and Council roads to point near Indian Valley.

T. 14 N., R. 1 W., on line between secs. 26 and 35, on Van Wyck, Midvale, and Indian Valley road, at Hillsdale crossroads, 150 feet east of white schoolhouse, at northwest corner of fence, 30 feet east of road, in volcanic bowlder near mound of rocks; aluminum tablet stamped "3164 W"	3,165.559
Van Wyck, 34.4 miles northwest of, on Van Wyck, Midvale, and Indian Valley road, 100 feet north of Little Weiser River; nail in knuckle of cottonwood 20 feet west of road	3,029.16
Indian Valley, near corner of secs. 10, 11, 14, and 15, T. 14 N., R. 1 W., southwest corner of blacksmith shop, east side of Main Street, in volcanic bowlder; aluminum tablet stamped "2999 W"	3,000.889
Indian Valley, 3.7 miles north of, near center of sec. 27, T. 15 N., R. 1 W., on Indian Valley-Council road, at foot of Thorn Creek Hill, 150 feet north of Thorn Creek, 100 feet west of road, 500 feet east of Sam Wood's house, near mound of rocks, in bowlder; aluminum tablet stamped "2931 W"	2,932.948
Indian Valley, 6.2 miles north of, NW. ¼ sec. 15, T. 15 N., R. 1 W., on Indian Valley-Council road, on middle fork of Weiser River Summit, 30 feet east of road, near mound of rocks, in granite bowlder; aluminum tablet stamped "3309 W"	3,310.911
Indian Valley, 7.3 miles north of, on Indian Valley-Council road, 50 feet south of creek, 3 feet east of bridge crossing Middle Fork Creek, in cottonwood; nail	2,903.95

SQUAW CREEK QUADRANGLE.

Bench mark in T. 13 N., R. 1 W.

	Feet.
Van Wyck, 29.6 miles west of, T. 13 N., R. 1 W., 500 feet northeast of crossroads, 100 feet east of Van Wyck-Indian Valley road, in top of volcanic bowlder beside mound of rocks; aluminum tablet stamped "3395 W"	3,396.379

Point 11.7 miles west of Van Wyck southwest to Canyon Hill, sec. 27, T. 13 N., R. 1 E., thence northwest along Indian Valley road to junction of Midvale road.

Van Wyck, 12.8 miles west of, 30 feet east of Van Wyck-Indian Valley road, in tree; nail	5,906.80
Van Wyck, 12.8 miles west of, 20 feet east of Van Wyck-Indian Valley road, in tree; 30-penny nail	5,637.20
Van Wyck, 13.6 miles west of, 30 feet east of Van Wyck-Indian Valley road, in pine tree; 30-penny nail	5,948.81
Van Wyck, 15.3 miles west of, 50 feet south of Van Wyck-Indian Valley road, on Four-bit Summit, near mound of rock, in volcanic rock; aluminum tablet stamped "6154 W"	6,155.170
Van Wyck, 16.6 miles west of, 10 feet west of Van Wyck-Indian Valley road, in pine tree; 30-penny nail	5,372.11
Van Wyck, 17.9 miles west of, 70 feet north of Van Wyck-Indian Valley road, in pine tree; 30-penny nail	4,743.51
Van Wyck, 19.1 miles west of, 10 feet north of Van Wyck-Indian Valley road, in pine tree; 30-penny nail	4,494.42
Van Wyck, 19.2 miles west of, 0.5 mile west of Courtright's house, 60 feet south of Van Wyck-Indian Valley road, in top of volcanic bowlder, near mound of rocks; aluminum tablet stamped "4464 W"	4,464.983
Van Wyck, 20.4 miles west of, in pine tree, 40 feet north of Van Wyck-Indian Valley road; 30-penny nail	4,136.58
Van Wyck, 21.6 miles west of, 150 feet south of Van Wyck-Indian Valley road, on Canyon Hill Summit, in volcanic bowlder, near mound of rocks; aluminum tablet stamped "4375 W"	4,376.422
Van Wyck, 23 miles west of, on Van Wyck-Indian Valley road; chisel mark on top of bowlder, 2 by 2 by 3 feet	3,833.51
Van Wyck, 26 miles west of, 0.4 mile southeast of junction of Indian Valley and Midvale roads, in rim of rock, in top of volcanic rock; aluminum tablet stamped "3409 W"	3,410.541

Little Weiser River west along Midvale road to McMahan ranch.

Indian Valley-Midvale crossroads, 4.2 miles west of, at J. W. Stippich's ranch, 100 feet northeast of house, in corner of yard, in volcanic bowlder; aluminum tablet stamped "3230 W"	3,231.166

St. Anthony and Victor quadrangles.

BINGHAM AND FREMONT COUNTIES.

The elevations in the following list are the results of leveling by Goyne Drummond in 1899 from St. Anthony, Idaho, to the Grand Teton and Mount Leidy quadrangles, Wyo., and were originally published in the Twenty-first Annual Report. In 1906 connection was made with the transcontinental line of the Coast and Geodetic Survey leveling by a line brought north from Green River and Rock

Springs, Wyo., to Twogwotee Pass and to a point 12 miles northeast of Kroner ranch, and readjustment was made between these points.

VICTOR QUADRANGLE.

Idaho-Wyoming State line at Trail Creek via Victor to Rigby's house.

	Feet.
Idaho-Wyoming State line, at Trail Creek, 8 feet north of road; bronze tablet stamped "B. M. 6681"	6,683.580
Spencer's house, 30 feet west of, 20 feet east of road, 250 feet north of Moses Creek; bronze tablet	6,477.700
Victor, northeast corner of Porter's store; iron post	6,207.582
Chapin's ranch, 60 feet east of house; iron post	6,145.989
Chapin's ranch, 2 miles northwest of, 100 feet north of channel of Darby Creek, 20 feet east of road; iron post	6,124.608
Drigg's house, 40 feet east of; iron post	6,099.209
Rigby's house, 1,000 feet northwest of, at milepost 192, Wyoming-Idaho State line; iron post	6,404.151

Drigg's ranch via Kimball's and Swanner's ranches to Teton Bridge.

Kimball's house, 1,150 feet southwest of; iron post	6,107.743
Swanner's yard, northeast corner of; iron post	5,976.158

Drigg's ranch to point 5.4 miles northwest of Teton Bridge.

Drigg's ranch, 3.5 miles north of, 80 feet east of new house; iron post	6,158.321
Lathron's house, 50 feet east of, 300 feet south of ford, T. 6 N., R. 45 E., east of southwest corner of sec. 28, north side of road; iron post	6,064.717
Teton Bridge, 400 feet east of, 6 feet from northwest corner of Alex West's house; iron post	5,932.255
Teton Bridge, 3.4 miles northwest of, top of divide between Teton River and Mill Creek; iron post	6,194.980
Teton Bridge, 5.4 miles northwest of, 20 feet west of Milk Creek, 600 feet south of road fork; iron post	6,071.942

ST. ANTHONY QUADRANGLE.

Point 5.4 miles northwest of Teton Bridge to St. Anthony.

Teton Bridge, 7.9 miles northwest of, top of divide between Milk Creek and Canyon Creek, 300 feet southwest of trail from Milk Creek; bronze tablet	6,024.386
Harris ranch, 3 miles northeast of, 30 feet north of road; iron post	5,908.169
Harris ranch, 10 feet northeast of house; iron post	5,641.554
St. Anthony, 120 feet to left of station 1956+50, Oregon Short Line Railroad elevation corrected to sea level, 5,010.49 feet; U. S. G. S. elevation	4,958.665

Montpelier, Pocatello, Soda Springs, and Wayan quadrangles.

BANNOCK AND BEAR LAKE COUNTIES.

The elevations in the following list are results of part of the leveling done in 1909 in Idaho, Utah, and Wyoming, and are based on a bench mark of the Coast and Geodetic Survey near Onyx, Bannock County, Idaho, the first given in the following list. The elevation of this bench mark is accepted as 4,619.392 feet above mean sea level. From Onyx the line was run over the Oregon Short Line Railroad to a point 3.5 miles south of Montpelier, thence south by road via Laketown and Randolph, Utah, to Evanston, Wyo., closing on the Coast and Geodetic Survey bench mark at that point.

The leveling was done by L. F. Biggs. The closure errors of this line and circuits are excessive.

Additional elevations in the Montpelier quadrangle will be found in the Wyoming lists.

POCATELLO QUADRANGLE.

Point near Onyx along Oregon Short Line Railroad to Pebble.

	Feet.
Onyx, 1 mile north of, near signboard "1 mile to Onyx," west of third telephone pole south of milepost 197, 24 feet west of right of way fence on west side of track, red stone post 6 feet long and 6 inches square; bottom of square hole cut in top marked "U. S. □ B. M." (Coast and Geodetic Survey bench mark and 1911 preliminary adjustment value)	4, 619. 392
McCammon, opposite station; top of east rail	4, 749. 5
McCammon, opposite point on the tracks 150 feet north of station, 20 feet southeast of third telephone pole north of schoolhouse, 225 feet west of track, 4 feet from fence on west side of main highway, in red stone post 6 feet long and 6 inches square; square cut hole marked "U. S. □ B. M." (Coast and Geodetic Survey bench mark)	4, 753. 742
McCammon, southeast corner of McCammon Investment Co. building, 3 feet above ground in corner stone; aluminum tablet stamped "4767 B 1909 A"	4, 767. 081
McCammon, 2.6 miles southeast of, west side of track at turn east, in concrete foundation of semaphore 1888; aluminum tablet stamped "4834 B 1909 B"	4, 834. 003
McCammon, 6.1 miles east of, 1 mile west of Topaz station, south side of track, 250 feet east of road crossing, in concrete culvert; aluminum tablet stamped "4925 B 1909 C"	4, 925. 589
Topaz, 2.8 miles east of, 0.8 mile west of Renfro, concrete foundation of distant block signal 1818, 12 feet south of center of track; aluminum tablet	5, 017. 180
Lava, in front of station; top of rail	5, 147. 0
Lava, 0.2 mile north of, east side of track, in concrete foundation of semaphore 1772; aluminum tablet stamped "5155 B 1909 E"	5, 155. 072
Lava, 3.7 miles north of, east side of track, cemented in concrete foundation of semaphore 1734; copper nail and washer stamped "5225 B. M. F"	5, 225. 373

SODA SPRINGS QUADRANGLE.

Pebble along Oregon Short Line Railroad to Rose.

Pebble, 1.5 miles north of, edge of track, in concrete foundation of semaphore 1682; aluminum tablet stamped "5318 1909 B. G."	5, 318. 428
Bancroft, 3.4 miles west of, south side of track, in concrete foundation of semaphore 1652; aluminum tablet stamped "5380 B 1909 H"	5, 380. 640
Bancroft, in northeast corner of brick schoolhouse, 4 feet above ground; aluminum tablet stamped "5417 1909 BI"	5, 418. 323
Bancroft, in front of station; top of rail	5, 421. 9
Bancroft, 4 miles east of, north side of track, in concrete foundation of semaphore 1581; aluminum tablet stamped "5502 B 1909 J"	5, 503. 484
Way, in front of station; top of rail	5, 585. 2

	Feet.
Alexander, 1.9 miles west of, south side of track, in concrete foundation of semaphore 1540; aluminum tablet stamped "5668 B 1909 K"	5, 669. 024
Alexander, in front of station; top of rail	5, 731. 8
Soda Springs, 4 miles west of, west edge of track, in concrete foundation of semaphore 1496; aluminum tablet stamped "5730 B 1909 L"	5, 730. 963
Soda Springs, in front of station; top of south rail	5, 777. 6
Soda Springs, southwest corner of schoolhouse, 4 feet above ground; aluminum tablet stamped "5777 B 1909 M"	5, 777. 860
Soda Springs, 4 miles southeast of, south side of track, in concrete foundation of semaphore 1422; aluminum tablet stamped "5808 B 1909 N"	5, 808. 296

WAYAN QUADRANGLE.

Rose along Oregon Short Line Railroad to Novene.

Rose, 1.5 miles southeast of, southwest corner of bridge over Bear River in concrete abutment; aluminum tablet stamped "5807 B 1909 O"	5, 808. 198
Manson, 2.3 miles southeast of, south side of track, in concrete foundation of semaphore 1336; aluminum tablet stamped "5853 B 1909 P"	5, 853. 320
Novene, 0.6 mile northwest of, southeast corner of bridge over Bear River, in abutment; aluminum tablet stamped "5881 B 1909 Q"	5. 882. 163

MONTPELIER QUADRANGLE.[1]

Novene along Oregon Short Line Railroad to point 3.5 miles south of Montpelier, thence south along road on east side of Bear Lake to Idaho-Utah State line.

Novene, in front of station; top of rail	5, 889. 0
Woley's spur, 1 mile northwest of, southwest corner of bridge 137 over Bear River, in stone abutment; aluminum tablet stamped "5904 B 1909 R"	5, 903. 439
Pescadero, 1 mile northwest of, south side of track, in concrete foundation of semaphore 1218; aluminum tablet stamped "5923 B 1909 S"	5, 923. 794
Pescadero, in front of station; top of rail	5, 921. 5
Montpelier, 4.6 miles northwest of, southeast corner of bridge over Bear River, in concrete foundation; aluminum tablet stamped "5914 B 1909 T"	5, 914. 969
Montpelier, in front of station; top of west rail	5, 940. 8
Montpelier, southeast corner of First National Bank building, on step at entrance to bank; aluminum tablet stamped "5944 B 1909 U"	5, 945. 815
Montpelier, 3.4 miles southeast of, east edge of right of way, at road crossing, in fence corner; iron post stamped "5951 B 1909 V"	5, 952. 301
Dingle, north end of town, at bend of road, opposite Bridge's ranch house, southwest corner of house yard; iron post stamped "5954 B 1909 W"	5, 955. 630
Meckley Lake; surface of water, June 1, 1909	5, 926. 0
Dingle, 2.9 miles south of, 1,000 feet south of Meckley Lake, 50 feet south of sheep pens, 150 feet west of road; iron post stamped "5939 B 1909 X"	5, 940. 562
Mud Lake, surface of water in; June 1, 1909	5, 924. 2
Hot Springs, 1.6 miles north of, west edge of road, opposite Mini tunnel, on bowlder painted "5928 B. M. 72"; chisel point	5, 929. 90
Hot Springs, 500 feet west of north-south road, 100 feet south of Turnpike post office, west end of large gate to yard; iron post stamped "5947 B 1909 Y"	5, 948. 178
Bear Lake, east shore; surface of water, May 31, 1909, light west wind prevailing	5, 924. 3
Hot Springs, 1 mile south of, north end of row of poplar trees, 300 feet north of house, in base of 20-inch poplar tree; spike with aluminum tag stamped "5980 B. M. 73"	5, 981. 75

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[1] Additional elevations in this quadrangle will be found in Wyoming list.

	Feet.
Hot Springs, 3.5 miles south of, opposite northeast corner of alfalfa field, at lane to barn; iron post stamped "5958 B 1909 Z"	5,960.008
Hot Springs, 5.7 miles south of, 250 feet west of road, on east shore of lake, 1,000 feet south of clump of small bushes at rocky point on shore, on bowlder painted "5925 B. M. 76"; chisel point	5,927.01
North Eden, 1.2 miles north of, 25 feet west of road, 150 feet east of small clump of trees, 100 feet east of lake; iron post stamped "5942 B 1909 A 1"	5,943.985
North Eden, 0.7 mile south of, at fence corner, 1,000 feet south of sheep sheds, west edge of road; iron post stamped "5958 B 1909 B 1"	5,959.763

Dingle along Oregon Short Line Railroad to Border.

Dingle, 1.6 mile south of, in southeast corner of concrete abutment of bridge 117 over creek; aluminum tablet stamped "5983 B 1909 32"	5,984,322
Harer, in front of station; top of rail	6,001.2
Pegram, 4.8 miles north of, 2,000 feet south of Harer station, opposite south end of siding, 100 feet west of right of way, on west side of wagon road; iron post stamped "5998 B 1909 33"	5,999.543
Pegram, 200 feet east of station, east edge of right of way, northwest corner of field, at road crossing; iron post stamped "6030 B 1909 34"	6,031.733
Pegram, 0.9 mile northeast of, northeast corner of steel bridge over Bear River, in cap; copper nail, with aluminum tag stamped "6042 B. M. 177"	6,043.30
Pegram, 2.6 miles northeast of, east edge of right of way, opposite milepost 95; iron post stamped "6048 B 1909 35"	6,048,849
Border, opposite section house, south side of track, 3 feet east of Idaho-Wyoming State line post; iron post stamped "6072 B 1909 30"	6,073.342

Montpelier by road via Geneva and Raymond to Border.

Montpelier, east side of steps of town hall, on first tier of concrete guard rail; aluminum tablet stamped "5962 B 1909 21"	5,963.350
Montpelier, 4.4 miles east of, north end of dam, at city water works, in top; aluminum tablet stamped "6211 1909 B 22"	6,212.100
Montpelier, 8.4 miles east of, 600 feet southeast of junction of Star Valley and Geneva roads, 200 feet south of creek, on point of hill, 20 feet east of road iron post stamped "6444 B 1909 23"	6,444.837
Montpelier, 9.5 miles east of, 0.7 mile east of junction of Star Valley and Geneva roads, 3 miles west of summit, south side of road, on bowlder painted "6608 B. M. 148"; chisel point	6,609.86
Montpelier, 11.2 miles east of, 20 feet east of road, 3 miles east of junction of Star Valley and Geneva roads, on summit of ridge between Montpelier and Geneva; iron post stamped "7000 B 1909 24"	7,001.153
Summit between Montpelier and Geneva, 2 miles east of, 15 feet south of road, on bowlder painted "6310 B. M. 151"; chisel point	6,311 02
Summit between Montpelier and Geneva, 2.8 miles east of, 2 miles west of Geneva, 800 feet east of log house, at intersection of road to north, southwest corner of field; iron post stamped "6230 B 1909 25"	6,230.086
Geneva, near post office, 150 feet east of northwest corner of field, at intersection of north-south road; iron post stamped "6171 B 1909 26"	6,171.811
Geneva, 3.6 miles south of, 3.2 miles northeast of Raymond, south side of east-west road, 20 feet west of canal; iron post stamped "6205 B 1909 27"	6,206.057
Raymond, 1,500 feet south of schoolhouse, at section corner, junction of east-west road; iron post stamped "6133 B 1909 28"	6,134.138
Raymond, 3 miles south of, on section line, 0.25 mile east of Idaho-Wyoming State line, northwest corner of alfalfa field belonging to J. Francis, 15 feet south of gate to lane; iron post stamped "6107 B 1909 29"	6,108.221

Montpelier via Ovid, Paris, and St. Charles to Turnpike (Hot Springs).

	Feet.
Montpelier, 1.7 miles west of, northeast corner of steel bridge over Bear River, in concrete abutment; bolt head painted "5925"	5, 925. 97
Montpelier, 3 miles west of, 350 feet west of bridge over slough, southeast corner of field at junction of roads; iron post stamped "5922 B 1909 36".	5, 923. 880
Ovid, southwest corner of school yard, at road junction; iron post stamped "5932 B 1909 37"	5, 933. 430
Paris, southwest corner of county courthouse, 5 feet above ground; aluminum tablet stamped "5966 B 1909 38"	5, 967. 084
St.Charles, 3 miles north of, northeast corner of field, at junction of road to west, 60 feet south of log barn at Joe Patterson's ranch, 300 feet north of creek; iron post stamped "5962 B 1909 39"	5, 963. 890
St. Charles, northeast end of town, west edge of road, opposite intersection of Paris and turnpike roads, 35 feet east of frame house, on fence line; iron post stamped "B 1909 5953 40"	5, 954. 928
St. Charles, 3 miles east of, 4 miles west of Hot Springs, 50 feet west of outlet of Bear Lake, on turnpike road; iron post stamped "5927 B 1909 41".	5, 928. 410
Bear Lake, surface of water, July 19, 1909; (light south winds and light waves, poor level)	5, 924. 1
Mud Lake; surface of water, July 19, 1909	5, 924. 1

Hailey, Picabo, Sawtooth, and Soldier quadrangles.

BLAINE COUNTY.

The elevations in the following list are approximate and are based on the height of the top of rail in front of the station at Hailey, determined by the Oregon Short Line Railroad.

The leveling was done in 1896 by A. B. Searle.

HAILEY QUADRANGLE.

Bench mark established at Hailey Hot Springs.

	Feet.
Hailey Hot Springs, at southwest corner of porch of hotel; iron post stamped "5418"	5, 418. 534

Bench marks along Warm Springs Creek.

Upper Hot Springs, at northwest corner of old cabin, on northeast side of road, about 20 yards from creek crossing; iron post stamped "6286"	6, 286. 317
Punch Bowl Lakes, about 1.2 miles above, on southeast side of road; iron post stamped "6010"	6, 010. 747
Ketchum, bridge across Wood River, east end of, in top of large rock abutment; bronze tablet stamped "5819"	5, 819. 686

Ketchum south along Oregon Short Line Railroad to Hailey.

Cold Springs mill, about 0.2 mile south of, at Point of Rocks; iron post stamped "5690"	5, 689. 836
Gimlet, discontinued post office, in front yard of east building; iron post stamped "5544"	5, 543. 733
Becker's ranch, at fence corner west of railroad track, about 20 yards south of road crossing; iron post stamped "5465"	5, 465. 166

Ketchum north along Sawtooth road.

Ketchum, 2.5 miles north of, first bridge over Wood River, not on main road, about 40 feet northeast of east end, west of road; iron post stamped "5949"	5, 948. 921

	Feet.
Ketchum, 8.5 miles north of, about 90 feet north of third bridge over Wood River, 30 feet east of wagon road; iron post stamped "6236"	6, 235. 937
Ketchum, 10 miles northwest of, south of wagon road, beyond crossing of dry wash, in center of large flat; cross on small basalt rock	6, 315. 4

PICABO QUADRANGLE.

Hailey along Camas Prairie road to Doniphan.

Gilman, side of house where post office was formerly located, near forks of road; iron post stamped "5547"	5, 547. 023
Kelly Creek crossing, 50 feet west of; iron post stamped "5857"	5, 856. 922
Divide between Croy and Camp creeks, south side of road; iron post stamped "6114"	6, 114. 866
Doniphan, south side of post office building, used also as assay office of Camas No. 2 mine; iron post stamped "5788"	5, 788. 444

SOLDIER QUADRANGLE.

Bench marks established along Willow Creek.

Willow Creek road and short cut to Soldier, forks of, about 50 feet west of a lone tree at edge of small drain; iron post stamped "5094"	5, 093. 974
Willow Creek and Soldier roads, about 4 miles north of intersection of, house of A. B. Arnold, at west side of county road, near rail fence at end of bars; iron post stamped "5298"	5, 297. 747
Willow Creek and Buttercup mine roads, junction of, southeast corner of log house; iron post stamped "5530"	5, 530. 596

Smoky District to head of Soldier Creek.

Trail Creek and branch of Soldier Creek, divide between; iron post stamped "7082"	7, 081. 932
T. 14 E., R. 1 N, south line of sec. 9, near Soldier Creek, at southeast corner of John Wordrupp's corral, about 20 feet west of forks of Soldier and Trail Creek roads; iron post stamped "5366"	5, 365. 63
Soldier Creek, near, 30 yards northwest of little log cabin, west side of wagon road where road makes right-angle turn after crossing creek near clump of quaking asps; iron post stamped "5755"	5, 755. 02
Soldier Creek, near, 2 miles west of mill, near cluster of big rocks, about 20 yards from large fir tree and 30 yards south of trail; iron post stamped "6558"	6, 558. 089

SAWTOOTH QUADRANGLE.

Divide between Willow Creek and Smoky Creek to Castle Crag.

Willow Creek and Smoky Creek divide, highest point of, about 200 feet east of road; iron post stamped "6857"	6, 857. 009
Soldier road, junction with, opposite Soldier road crossing of Little Smoky Creek, in top of bowlder; bronze tablet stamped "6365"	6, 364. 689
Carrie Leonard road, junction with, west side of road, about 0.5 mile north of junction of Carrie Leonard and Little Smoky creeks; iron post stamped "6123"	6, 123. 185
Carrie Leonard Creek and Warm Springs Creek, divide between; iron post stamped "8719"	8, 718. 579
Summit where Warm Springs Creek crosses road, about 3.5 miles east of, on south side of road and near a group of large stumps; iron post stamped "7281"	7, 281. 377
Castle Crag, 50 feet east of base of, at west side of road, midway between two creek crossings; in top of rock; bronze tablet stamped "6640"	6, 640. 174

Smoky District along south Boise trail toward Atlanta.

	Feet.
Worswick's, 1.5 miles from, about 100 yards east of trail; iron post stamped "7148"	7,148.267
Little and Big Smoky creeks, junction of, about 200 yards south of forks of South Boise and Big Smoky trails, in east face of rock, about 50 feet above general elevation of valley; copper bolt stamped "5539"	5,539.014
Big Smoky Creek, about 3.5 miles from junction with Little Smoky Creek, on rocky point about 100 feet above creek and about 20 yards southwest from lone fir tree; iron post stamped "5822"	5,821.759
South Boise Creek, 3.8 miles above placer claim, near lone fir tree at south side of trail on flat, and 50 yards east of creek; iron post stamped "5773"	5,772.815
South Boise Creek, about 9.5 miles above placer claim, at south side of trail and at base of large accumulation of slide rock, at point where the canyon begins to narrow, and where trail goes down to creek; iron post stamped "6169"	6,169.593

Point 13.5 miles northwest of Ketchum up Wood River to divide between Wood and Salmon rivers.

Ketchum, about 13.5 miles northwest of, about 40 feet north of abandoned stable on top of small knoll at south end of road and west of road crossing of Bowlder Creek; iron post stamped "6596"	6,595.866
Ketchum, 17.5 miles northwest of, 300 feet west of seventh bridge over Wood River, at top of wagon grade on north side of road; iron post stamped "7020"	7,019.766
Galena, near southeast corner of second building west of road; iron post stamped "7294"	7,294.195
Galena, 1.2 miles west of, about 70 feet before road crosses stream; cross mark on large rock west of road	7,426.2
Wood River and Salmon River, divide between, 50 feet northwest of road; iron post stamped "8795"	8,795.582

Chatcolet Station, Kendrick, and Pullman quadrangles.

KOOTENAI AND LATAH COUNTIES.

The elevations in the following list were determined by primary leveling extended from an aluminum tablet in the top of latitude pier in the grounds of the county courthouse at Spokane, the elevation of which is now accepted as 1,891.954 feet above mean sea level, as obtained by readjustment of a double-rodded line run in 1898 along the Northern Pacific Railway by H. S. Crowe.

The leveling was done in 1903 by E. M. Fry.

PULLMAN QUADRANGLE.

Bench mark at Moscow.

	Feet.
Moscow, 20 feet north of Northern Pacific Railway station, 5 feet west of platform, near coal house, 15 feet west of track; iron post stamped "2564 S"	2,564.873

KENDRICK QUADRANGLE.

Genesee via county road to Moscow.

Genesee, northeast corner of Main and Third streets, in brick wall at front entrance to First National Bank, 1 foot above sidewalk; bronze tablet stamped "2676 S"	2,676.945

Line along Thorn Creek road to Moscow.

	Feet.
Bangs, 2 feet from southeast corner of schoolhouse, in brick foundation, 3 feet north of steps; bronze tablet stamped "2745 S"	2,746.207
Snow's ranch, 1,000 feet southwest of house, 150 feet west of road at section corner, southeast corner of field, in rock ledge 3 feet above ground; bronze tablet stamped "2586 S"	2,587.552

CHATCOLET STATION QUADRANGLE.

Bench mark at Lovell.

Lovell, 150 feet west of section house, 100 feet east of railroad tool house, 10 feet west of milepost 407, 20 feet south of track; iron post stamped "2586 S"	2,587.882

Cataldo and Rathdrum 30′ quadrangles and Cœur d'Alene special quadrangle.

KOOTENAI AND SHOSHONE COUNTIES.

The elevations in the following list are based on primary leveling. The leveling in the Cataldo and Cœur d'Alene quadrangles was done in 1900 by F. E. Washburn, in 1901 by S. M. Hatch, and in 1905 by A. P. Anderson; that in the Rathdrum quadrangle was done in 1899 by M. P. Page.

RATHDRUM QUADRANGLE.

Bench marks established near Spirit Lake and Fish Lake.

	Feet.
Sullivan's ranch, south end of, 4 feet south of road, in root of 40-inch yellow-pine tree; tack	2,298.7
Spirit Lake, 200 feet east of landing, 15 feet south of road; iron post stamped "2490 S"	2,490.593
Spirit Lake, surface of water	2,442.6
Fish Lake, 1.5 miles north of, 4 feet west and south of forks of road, in top of bowlder 20 by 12 inches, 6 inches above ground; cross mark, "+"	2,429.4
Fish Lake, 600 feet east of, northeast of forks of roads, in top of bowlder 10 inches by 6 feet; cross mark, "+"	2,391.7
Fish Lake, surface of water	2,313.6
Fish Lake, 0.2 mile east of south end of, 80 feet south of fork of roads; iron post stamped "2366 S"	2,366.308

From point near Hauser Junction along Northern Pacific Railway to milepost "W. 204, H. 42."

Hauser Junction, 1.4 miles east of, 30 feet north of public road and 120 feet north of railroad, in south end of bowlder 40 by 30, inches above ground; bronze tablet stamped "2118 T"	2,119.193
Rathdrum, in front of station, top of rail	2,207.0
Rathdrum, in brick building (Russell's store), eighth tier of bricks above sidewalk; bronze tablet stamped "2216 T"	2,216.310
Milepost "W. 190, H. 56," 0.2 mile east of, 10 feet south of wagon road, 300 feet northeast of signboard "Sheridan" in notch of fir tree 18 inches in diameter; copper nail	2,271.85
Ramsey, 50 feet north of center of track, 3 feet east of telegraph pole, 20 feet east of wagon road; iron post stamped "2330 T"	2,330.828
Milepost "W. 196, H. 50," 215 feet northeast of, 100 feet north of railroad, in pine tree; copper nail	2,368.80
North Pole spur, 0.5 mile east of, 40 feet north of railroad track, 3 feet east of telegraph pole; iron post stamped "2396 T"	2,396.227

	Feet.
Milepost "W. 201, H. 45," 390 feet northeast of, 40 feet north of track, in north side of fir stump 24 inches in diameter; railroad spike	2, 376. 90
Athol, in front of railroad section house; center of track	2, 392. 1
Athol, 200 feet northeast of milepost "W. 202, H. 44," in notch of fir tree 24 inches in diameter; copper nail	2, 393. 40
Milepost "W. 204, H. 42," 13 feet west of, 20 feet west of center of track; iron post stamped "2350 T"	2, 350. 544

Hauser Junction via Northern Pacific Railway to Cœur d'Alene.

Post Falls, 150 feet south of woolen mill, 200 feet east of bridge over Spokane River, 100 feet west of railroad spur, in large bowlder 20 feet south of road; aluminum bolt stamped "2147 S"	2, 147. 903
Post Falls, 6 miles east of, 500 feet south of track, 8 feet southwest of telegraph pole; iron post stamped "2148 S"	2, 148. 196
Cœur d'Alene, corner of Sherman and Fourth streets, in southeast corner of Merriam building, 2 feet above sidewalk and 1 foot from door; aluminum tablet stamped "2157 S	2, 157. 909
Cœur d'Alene Lake, at Johnson's boat landing, in cottonwood tree at surface of water May 20, 1899; spike	2, 131. 1
Cœur d'Alene Lake; surface of water May 23, 1899	2, 130. 5
Cœur d'Alene Lake; surface of water, August 23, 1899	2, 122. 0
Post Falls, at dam; surface of Spokane River, August 23, 1899	2, 120. 1

Cœur d'Alene via King's ranch to Ramsey.

Cœur d'Alene, 1 mile north of, 20 feet west of road, 200 feet southwest of house, in pine stump; spike	2, 234. 69
Cœur d'Alene, 2 miles north of, 30 feet east of road, 200 feet northeast of road forks, in pine tree; spike	2, 235. 36
Cœur d'Alene, 3.5 miles north of, 40 feet north of forks of road, in gate post; spike	2, 254. 27
Cœur d'Alene, 4.3 miles north of, 40 feet northeast of road crossing, 80 feet southwest of schoolhouse, near corner of secs. 13, 14, 23, and 24, T. 51 N., R. 4 W., in pine tree; spike	2, 280. 60
Cœur d'Alene, 6.2 miles north of, 30 feet south of crossroads, at corner of secs. 1, 2, 11, and 12, T. 51 N., R. 4 W., in top of pine stump; spike	2, 314. 13
Cœur d'Alene, 7.2 miles north of, in pine bearing tree to secs. 1, 2, 35, and 36, Tps. 51 and 52 N., R. 4 W.; spike	2, 329. 73
Cœur d'Alene, 8.2 miles north of, 30 feet west of road at edge of timber, in pine tree; spike	2, 316. 31
Cœur d'Alene, 9.5 miles north of, 3 feet west of road, in root of pine stump 36 inches in diameter; spike	2, 285. 43

Cœur d'Alene to Fernan Lake.

Fernan Lake, 15 feet north of, 200 feet east of Fernan's house, on stone 20 by 30 by 20 inches; cross	2, 133. 66
Fernan Lake; surface of water, August 18, 1899	2, 129. 53

Rathdrum along telephone road to point on Cœur d'Alene branch of Northern Pacific Railway 2.5 miles east of Post Falls.

Rathdrum, 2.8 miles south of, corner common to secs. 12, 7, 13, and 18, T. 51 N., Rs. 4 and 5 W., on stone at foot of telephone pole; cross	2, 256. 07
Rathdrum, 3.8 miles south of, 20 feet northwest of crossroads, 300 feet northeast of Thornton's barn, corner common to secs. 13, 18, 24, and 19, T. 51 N., Rs. 4 and 5 W.; iron post stamped "2241 S"	2, 241. 833

Hauser Junction via county road to Hayden Lake.

	Feet.
Hauser Junction, 4 miles east of, in post southeast of corner of secs. 22, 23, 26, and 27, T. 51 N., R. 5 W.; spike	2,206.45
Hauser Junction, 5 miles east of, on stone set for corner of secs. 23, 24, 25, and 26, T. 51 N., R. 5 W.; cross	2,231.93
T. 51 N., R. 4 W., corner of secs. 15, 16, 21, and 22, 30 feet southeast of; iron post stamped "2293 S"	2,293.264
Hayden Lake, 40 feet west of, 200 feet east of gate to King's ranch, in pine tree; nail	2,262.00
Hayden Lake; surface of water, August 29, 1899	2,243.2

Corner of Tps. 51 and 52 N., Rs. 3 and 4 W., along township line north to Hayden Lake.

Corner of Tps. 51 and 52 N., Rs. 3 and 4 W.; iron post stamped "2424 S"	2,424.05
T. 52 N., R. 3 W., 30 feet east of quarter corner of S. ½ sec. 33; in root of fir tree; spike	2,465.46
Hayden Lake, 100 feet west of, 3 feet east of trail, on stone; cross	2,330.0

Corner of secs. 4, 5, 31, and 32, Tps. 51 and 52 N., R. 3 W., to Hudlow's ranch, on Hayden Lake.

Rim Rock, 300 feet northwest of schoolhouse, 60 feet north of road, in tamarack stump; spike	2,519.19
Hudlow's ranch, 25 feet northeast of house, 600 feet north of Hayden Lake; iron post stamped "2267 S"	2,267.846

Cœur d'Alene via French Gulch to Kelley's ranch.

Cœur d'Alene, 2 miles northeast of, 30 feet north of road and 50 feet west of bridge, in root of tamarack stump; nail	2,296.39
French Gulch, summit of hill east of, 10 feet north of road, 50 feet southeast of house, in root of pine stump; nail	2,521.92

West end of Spirit Lake along trail to Brickel's cabin.

Spirit Lake, 1 mile west of, 30 feet west of log cabin, 60 feet east of creek, 5 feet north of trail, in root of fir tree 24 inches in diameter; nail	2,456.07
Spirit Lake, 2 miles west of, 20 feet southeast of southeast corner of Brickel's cabin, 150 feet north of creek, in root of fir tree 10 inches in diameter; nail	2,476.07

Schoolhouse at east end of Eightmile Prairie, 2 miles south of Ramsey, east along county road to Pend Oreille Lake.

Schoolhouse at east end of Eightmile Prairie, 100 feet west of, 250 feet east of Northern Pacific Railway; iron post stamped "2385 S"	2.385.500
Schoolhouse at east end of Eightmile Prairie, 2 miles east of, 10 feet north of road at top of hill, in root of pine tree; nail	2,432.67
Schoolhouse at east end of Eightmile Prairie 4.8 miles east of, 15 feet north of road, in root of pine tree; nail	2,398.79
Schoolhouse at east end of Eightmile Prairie, 4 miles east of, 250 feet northwest of sawmill, 140 feet northwest of house; iron post stamped "2465 S"	2,465.608
Pend Oreille Lake, 8 feet east of road, 9 feet south of corner of fence, in root of cottonwood tree 10 inches in diameter; nail	2,071.09
Pend Oreille Lake; surface of water, September 22, 1897	2,055.5

Collin's ranch along road and Leiberg trail to Chilto Mountain.

Collin's ranch, 2.5 miles east of, 20 feet south of forks of roads, in root of fir tree 12 inches in diameter; nail	2,643.23
Collin's ranch, 3.5 miles east of, 4 feet north of trail at its beginning, 100 feet south of creek: iron post stamped "2684 S"	2,684.491

	Feet.
Leiberg Creek and Iron Gulch, top of divide between, 1 mile southwest of Chilco triangulation station; iron post stamped "4944 S"	4,944.500

Ramsey via Seneaguoteen and Rathdrum road to Sheep Springs.

Ramsey, 1 mile north of, 30 feet west of road, in root of pine tree; nail	2,353.30
Ramsey, 2.8 miles north of, 10 feet west of road, 100 feet west of fork of roads; iron post stamped "2424 S"	2,424.629
Ramsey, 4.3 miles north of, 30 feet west of fork of roads, 5 feet west of road, in root of pine tree; nail	2,440.22
Ramsey, 5 miles north of, 40 feet north of road, 60 feet northeast of fork of roads, in root of pine tree; nail	2,437.49
Ramsey, 5.8 miles north of, 25 feet northeast of crossroads; iron post stamped "2491 S"	2,491.449
Ramsey, 7.5 miles north of, 30 feet west of road, in root of tree; nail	2,521.38
Sheep Springs, 200 yards southwest of, 15 feet north of road, in root of fir tree; nail	2,486.24

Cœur d'Alene via Wolf Lodge to Fourth of July Canyon.

Cœur d'Alene, 2.8 miles southeast of, 60 feet southwest of fork of roads, on stone 30 by 20 by 12 inches; cross	2,504.445
Cœur d'Alene, 3 miles southeast of, 45 feet south of road at summit of hill; iron post stamped "2691 S"	2,691.893
Cœur d'Alene, 4.5 miles southeast of, 60 feet east of creek, 10 feet north of road, in fir tree; nail	2,545.83
Cœur d'Alene, 6.7 miles southeast of, 5 feet north of road, 50 feet east of fork of roads, in fir tree; nail	2,162.86
Wolf Lodge, 60 feet west of Johnson's house in yard, 200 feet east of Wolf Lodge Creek ford; iron post stamped "2155 S"	2,155.092
Wolf Lodge, 1.2 miles east of, 5 feet north of road, 300 feet north of drain, in root of fir tree; nail	2,339.00
Fourth of July Canyon and Cedar Creek, top of divide between, 40 feet north of road; iron post stamped "3136 S"	3,137.062

Harrison along track of Oregon-Washington Railroad & Navigation Co. to Lane.

Harrison, base of fence around residence of M. Ribstene, in sixth tier of stone wall; aluminum tablet stamped "2207 S"	2,206.970
Lane, 600 feet southeast of post office and station, 40 feet north of house, in granite bowlder 24 by 36 by 40 inches; aluminum bolt stamped "2153 S"	2,153.438

Len Landing via Bellgrove to State line.

Len Landing, 1 mile southwest of, 10 feet north of road, in root of fir tree; nail	2,530.36
Len Landing, 2.1 miles southwest of, 6 feet south of trail on summit of mountain, in root of pine tree; nail	2,070.37
Len Landing, 3.2 miles southwest of, 6 feet south by 100 feet west of crossroads, in root of fir tree; nail	2,502.81
Bellgrove, 1 mile south of, 20 feet east of an old deserted cabin, 100 feet north of fork of roads; iron post stamped "2411 S"	2,411.994
Bellgrove, 2 miles southwest of, 5 feet west of road, 20 feet south of fork of roads, in root of fir tree; nail	2,464.55
Three Pine Springs, 1.1 miles west of, 20 feet south of road, at summit of hill, in root of fir tree; nail	2,753.54

Bellgrove via Mica Bay to Post Falls.

	Feet.
Bellgrove, 0.9 mile north of, 15 feet east of road at summit of divide, 600 feet north of B. F. Williams's house; iron post stamped "2585 S"	2,585.372
Bellgrove, 2.1 miles north of, 24 feet north of creek, 500 feet southeast of barn, 20 feet east of fence, in root of fir tree; nail	2,331.21
Bellgrove, 2.8 miles north of, 60 feet west of creek, in root of white pine tree; nail	2,290.32
Bellgrove, 5.8 miles north of, 100 feet south of house, on rock 20 by 10 by 7 inches; cross	2,149.91
Mica Bay, 0.8 mile north of, 20 feet northwest of fork of roads, on stone 36 by 24 by 18 inches; cross	2,471.57
Mica Bay, 1.2 miles north of, 10 feet west of forks of roads on summit of hill, in root of pine tree; nail	2,571.32
T. 49 N., R. 4 W., 30 feet east of quarter corner between secs. 4 and 5; iron post stamped "2578 S"	2,578.170
Cougar Creek, 2 miles northwest of, 12 feet south of road, on summit of divide between Spokane River and Cougar Creek, 800 feet north of cabin; iron post stamped "2810 S"	2,810.936
Spokane River, 0.5 mile south of, 25 feet southeast of fork of roads, in root of pine tree; nail	2,139.44
Post Falls, 1.5 miles southeast of, 15 feet south of ferry over Spokane River, in root of pine tree; nail	2,121.59

Various high summits determined by vertical angles.

Cœur d'Alene, 7.5 miles southeast of, 4.5 miles east of Echo Bay, on summit of highest roundtop point, in stone 20 by 20 inches; aluminum bolt stamped "4440 S"	4,440.5
Cœur d'Alene, 10 miles southwest of, Skalan triangulation station, on summit of high roundtop bald peak, in rock 2 feet by 1 foot; copper bolt stamped "5250 S"	5,250.5
Cœur d'Alene, 10 miles northeast of, summit of high roundtop burnt point at head of Wolf Lodge Creek, in large bowlder; aluminum bolt stamped "4851 S"	4,851.5
Rathdrum, 3 miles north of, on high roundtop burnt peak known as "Rathdrum Bald," in bowlder; aluminum bolt stamped "4970 S"	4,970.5
Hayden Lake, 5.5 miles east of high roundtop burnt point, in rock; aluminum bolt stamped "5026 S"	5,026.5
Leiberg Creek and Iron Gulch, 1 mile northeast of divide between, at Chilco triangulation station; copper bolt stamped "5625"	5,625.5

CATALDO 30' QUADRANGLE AND CŒUR D'ALENE SPECIAL QUADRANGLE.

Cataldo along road to mouth of Fourth of July Canyon.

Cataldo, 4 feet west of section house; iron post stamped "2143 S"	2,142.886
Cataldo, 1 mile northwest of, in base of telephone pole 1034; spike	2,135.450
Cataldo, 3 miles northwest of, 175 feet northwest of schoolhouse, in root of pine stump; nail	2,136.87
Cataldo, 3.7 miles northwest of, north of road at forks, in root of fir tree; nail.	2,152.09
Cataldo, 4.6 miles northwest of, 6 feet west of telephone pole 900, in root of stump; spike	2,205.57
Cataldo, 5.7 miles northwest of, south of road, 60 feet southwest of telephone pole 857, in root of fir stump; spike	2,257.54
Fourth of July Canyon, mouth of, 200 feet west of old barn, south of road opposite old cellar; iron post stamped "2160 S"	2,160.446

Kingston along trail via Little North Fork to Cascade Creek, thence northeast via Leiberg mine, Bear Creek, and Weber mine to Lake View.

	Feet.
Little North Fork of Cœur d'Alene River, 150 feet north of mouth of, 30 feet west of, on top of large cliff; iron post	2,204.880
Little North Fork of Cœur d'Alene River, 100 feet northwest of mouth of, 6 feet above water, on narrow projecting rock; cross	2,193.450
Kingston, 1 mile northeast of, 90 feet northeast of Oregon-Washington Railroad & Navigation Co. bridge, in root of cottonwood tree branching in two; nail	2,160.90
Delta, Murray, and Little North Fork roads, 210 feet east of intersection of, 40 feet south of creek at bend in road, in root of 12-inch pine tree; nail	2,532.48
Delta, Murray, and Little North Fork roads, 0.45 mile from intersection of, 20 feet north of creek, in root of fir tree; spike; marked "2436"	2,437.06
Delta, Murray, and Little North Fork roads, 1.2 miles from intersection of, 20 feet south of road, in root of pine tree; nail	2.260.99
Delta, Murray, and Little North Fork roads, 1.98 miles north of intersection of, 1,700 feet northwest of Jacobson's house, 30 feet west of road, in root of large cedar stump; nail marked "2195"	2,195.06
Ben Vener's house, 50 feet northwest of, in root of 24-inch fir tree; nail	2,199.25
Ben Vener's house, 1 mile northwest of, edge of trail between North Fork of Cœur d'Alene and Little North Fork rivers, in root of 20-inch pine tree; nail marked "2462"	2,462.44
North Fork and Little North Fork rivers, summit of trail between, 25 feet north of trail, in root of 26-inch fir tree; nail marked "2641"	2,641.58
North Fork Cœur d'Alene River, 1.25 mile from, 10 feet north of trail, 20 feet north of small rill, in root of 16-inch fir tree; nail marked "2515"	2,514.82
Little North Fork River, 500 feet northwest of, at edge of trail, in root of fir tree; nail marked "2380"	2,382.27
Canning's house, 880 feet north of, 150 feet northwest of Little North Fork River, 40 feet south of trail, in root of 36-inch cottonwood tree; nail marked "2205"	2,206.10
Canning's house, 0.5 mile north of, 80 feet west of Little North Fork River, 30 feet east of trail, in root of 34-inch cedar tree; nail marked "2212"	2,212.52
Glenwood, 40 feet west of log house, 300 feet northwest of Little North Fork River, in root of 12-inch fir tree; nail marked "2218"	2,218.42
Bumble Bee, east of river, in top of rock 12 feet above water; aluminum tablet stamped "2239 S"	2,239.444
Bumble Bee, 0.25 mile southwest of, 30 feet southeast of river, at edge of trail, in root of 36-inch cottonwood tree; nail marked "2241"	2,241.25
Bumble Bee, 0.8 mile northwest of, 10 feet west of river, at edge of trail at ford, in root of 30-inch cottonwood tree; nail marked "2245"	2,245.09
Bumble Bee, 1.5 miles northwest of, opposite high cliff at bend in river, on bank of river, in root of 24-inch cottonwood tree; nail marked "2250"	2,250.43
Bumble Bee, 2.8 miles northwest of, 1,600 feet south of cabin, 30 feet southwest of river, in root of 36-inch cedar tree; nail marked "2273"	2,273.39
Old Mission trail, intersection with Little North Fork of Cœur d'Alene River crossing, 20 feet south of river, in root of 36-inch fir tree; nail marked "2300"	2,300.06
Old Mission trail, 0.1 mile from, intersection with Little North Fork of Cœur d'Alene, 10 feet from north bank of river, in root of pine tree 30 inches in diameter; nail	2,306.29
Cox's logging camp, 70 feet east of, 50 feet west of Copper Creek, 30 feet west of Old Mission trail; iron post stamped "2335 S"	2,335.780
Cox's logging camp, 0.25 mile north of, 200 feet from Copper Creek, 10 feet east of trail, in root of 16-inch white pine tree; nail marked "2336"	2,336.85

	Feet.
Cox's logging camp, 1 mile north of, 20 feet southeast of Little North Fork River, at edge of trail where it makes first steep climb above Cox's camp, in root of 30-inch hemlock tree; nail marked "2357"	2,357.25
Little North Fork River, west side of stream, at base of cliff 300 feet high, 10 feet from three large cottonwood trees, in root of fir tree; nail marked "2388"	2,388.35
Old Mission trail, 20 feet north of, south bank of river, in root of 48-inch cedar tree; nail marked "2401"	2,401.88
Cox's lower logging camp, 3 miles northwest of, 50 feet south of river, 10 feet south of Old Mission trail; iron post stamped "2406 S"	2,406.773
Little North Fork River, south bank of stream at bend, at base of cliff 75 feet high, on shelving rock, in root of 18-inch hemlock tree; nail marked "2444"	2,444.97
Old Mission trail, 20 feet north of, 40 feet south of river, in root of 24-inch hemlock tree; nail marked "2467"	2,468.70
Little North Fork River, near bend at base of cliff 100 feet high projecting over river, in root of 36-inch cottonwood tree; nail marked "2481"	2,481.23
Little North Fork River, south bank of, clump of four trees, one partly cut by beavers, in root of cottonwood tree; nail marked "2502"	2,503.20
Leiberg and Old Mission trails, 200 feet west of intersection of, west bank of river, on large rock; cross marked "2540"	2,540.40
Leiberg and Old Mission trails, intersection of, 40 feet north of, 6 feet east of trail, in root of 20-inch hemlock tree; nail marked "2541"	2,541.78
Leiberg and Old Mission trails, 12 feet west of intersection of, 0.75 mile northwest of Handspike mine, 200 feet west of mouth of Leiberg Creek; iron post stamped "2541 S"	2,541.860
S. W. Cope's cabin, 250 feet northeast of, 10 feet north of river, 70 feet below crossing of Old Mission trail, in root of 30-inch cottonwood tree; nail marked "2558"	2,559.04
Prospector's cabin, 0.5 mile northwest of, south bank of river, at base of steep wooded slope, in root of 18-inch cedar tree; nail marked "2630"	2,631.36
Old Mission trail, 100 feet south of, on south bank of river, 400 feet above large riffle, in root of 30-inch cottonwood tree; nail marked "2673"	2,672.52
Old Mission trail, 170 feet south of, 50 feet east of large talus slope, south bank of river, in root of 24-inch cottonwood tree; nail marked "2692"	2,692.56
Old Mission trail ford, 200 feet north of, north bank of river at bend, in root of 12-inch black pine tree; nail marked "2717"	2,718.04
Skookum Creek, mouth of, on bank, in root of dogwood tree; nail marked "2732"	2,732.54
Old Mission and Cœur d'Alene trails, 10 feet east at intersection, 115 feet north of mouth of Deception Creek; iron post stamped "2740 S"	2,740.627
Old Mission and Cœur d'Alene trails, 0.5 mile north of intersection, 200 feet northeast of ford of Old Mission trail, north bank of river, in root of 20-inch white pine tree; nail marked "2754"	2.754.79
Old Mission and Cœur d'Alene trails, 1.5 miles north of intersection of, 20 feet east of river, 6 feet west of Old Mission trail, in root of white pine tree; nail marked "2792"	2,792.89
Cascade Canyon, mouth of, 240 feet south of mouth of Cascade Creek, 30 feet east of river, edge of trail at ford, in root of large pine stump; nail marked "2834"	2,834.62
Cascade Creek, 230 feet south of mouth, 80 feet east of river, 10 feet east of forks of trail; iron post stamped "2837 S"	2,837.547
Cascade Canyon, 0.8 mile northeast of mouth of, 400 feet northeast of cabin, edge of trail, in root of 30-inch white pine tree; nail marked "2912"	2,912.58

	Feet.
Cascade Canyon, 1.2 miles northeast of mouth of, 20 feet south of trail, in root of 38-inch white pine tree; nail marked "2980"	2,980.76
Moore's cabin, 0.8 mile southwest of, between trail and creek, in root of white pine tree 36 inches in diameter; nail marked "3155"	3,156.26
Moore's cabin, 0.5 mile southwest of, 10 feet north of trail, 30 feet south of cabin, in root of 24-inch hemlock tree; nail marked "3293"	3,293.82
Moore's cabin, 340 feet south of, 30 feet east of small creek, 6 feet north of trail, in root of 32-inch hemlock tree; nail marked "3346"	3,347.10
Moore's cabin, 1,700 feet northeast of, 5 feet south of trail, in root of 24-inch hemlock tree; nail marked "3437"	3,438.35
Moore's cabin, 0.6 mile northeast of, edge of trail, in root of hemlock tree; nail marked "3642"	3,643.33
Moore's cabin, 1.5 miles northeast of, north edge of trail, in root of 12-inch fir tree; nail marked "3900"	3,900.36
Moore's cabin, 1.8 miles northeast of, edge of trail, in root of 10-inch white pine tree; nail marked "4144"	4,148.50
Moore's cabin, 1.9 miles northeast of, edge of trail, in root of 20-inch white pine tree; nail marked "4300"	4,301.09
Moore's cabin, 2 miles northeast of, at forks of trail and beginning of second switchback, in root of 20-inch fir tree; nail marked "4473"	4,473.79
Moore's cabin, 2.25 miles northeast of, 60 feet above last switchback, edge of trail, in root of 18-inch black pine tree; nail marked "4661"	4,662.00
Moore's cabin, 2.25 miles northeast of, 800 feet south of Leiberg mine, edge of trail, in root of 24-inch white pine tree; nail marked "4665"	4,666.59
Leiberg mine, 0.5 mile south of, edge of trail, in root of black pine tree 10 inches in diameter; nail marked "4809"	4,809.65
Leiberg mine, 0.8 mile south of, 300 feet west of summit of trail, 6 feet north of trail, in root of 10-inch black pine tree; nail marked "5100"	5,100.64
Leiberg mine, 0.8 mile south of, top of summit in large rock, 20 feet south of trail; aluminum tablet stamped "5127 S"	5,127.864
Leiberg mine, 0.9 mile southeast of, 6 feet south of trail, at base of rocky knoll, in root of white pine tree; nail marked "5094"	5,094.68
Summit of trail, 1,600 feet northeast of, 18 feet north of trail, on steep smooth slope, in root of black pine tree; nail marked "4919"	4,920.495
Leiberg mine, 1 mile southeast of, 0.5 mile east of summit of trail, 3 feet north of trail, in root of 12-inch black pine tree; nail marked "4926"	4,926.796
Leiberg mine, 1.25 miles southeast of, south edge of trail, in root of fir tree; nail marked "4822"	4,822.846
Leiberg mine, 1.8 miles east of, in low sag on ridge, 3 feet south of trail, in root of 12-inch white pine tree; nail marked "4457"	4,458.21
Leiberg mine, 3 miles southeast of, top of last summit between Cascade and Trail creeks, on top of large white quartz bowlder 30 feet south of trail; cross marked "4581"	4,582.56
Leiberg mine, 3.1 miles southeast of, 400 feet southeast of last summit on trail between Cascade and Trail creeks, in root of 10-inch hemlock tree; nail marked "4522"	4,523.25
Leiberg mine, 3.25 miles southeast of, edge of trail, in root of 16-inch white pine tree; nail marked "4439"	4,440.20
Leiberg mine, 4 miles southeast of, 1 mile southeast of last summit on trail, edge of trail, in root of 10-inch white pine tree; nail marked "4169"	4,170.14
Leiberg mine, 4.5 miles southeast of, 0.5 mile west of Trail Creek, 3 feet south of trail, in root of 12-inch hemlock tree; nail marked "4001"	4,002.13
Leiberg mine, 4.8 miles southeast of, 500 feet east of Teany's cabin, 1,200 feet west of Trail Creek, 3 feet south of trail, in root of white pine tree; nail marked "3802"	3,803.57

	Feet.
Webb's cabin, 0.25 mile south of, 800 feet west of Trail Creek, on sharp ridge sloping down to creek, 3 feet west of trail, in root of 24-inch red fir tree; nail marked "3571"	3,572.66
Webb's cabin, 120 feet southeast of, 100 feet west of Trail Creek, SW. ¼ sec. 29, T. 52, R. 1 E., 3 feet west of trail, in root of 12-inch white pine tree, nail marked "3332"	3,333.61
Webb's cabin, 0.2 mile east of, 100 feet east of Trail Creek, 8 feet east of forks of trail; iron post stamped "3273 S"	3,274.068
Trail Creek, 50 feet east of, 2,000 feet north of McDarman's cabin, in root of 10-inch white fir tree; nail marked "3213"	3,214.27
Big Meadows, 6 miles southwest of, 20 feet east of Trail Creek, 3 feet south of trail, at lower end of large open meadow, in root of 30-inch spruce tree; nail marked "3195"	3,195.95
Big Meadows, 5 miles southwest of, 110 feet southeast of Trail Creek, 2 feet east of trail, in root of 16-inch white fir tree; nail marked "3147"	3,147.77
Big Meadows, 4.8 miles southwest of, 12 feet west of Trail Creek, 4 feet east of trail, in root of 36-inch spruce tree; nail marked "3137"	3,138.61
Heiner's cabin, 30 feet south of, 2.5 miles southwest of Big Meadows, 20 feet north of Trail Creek, in root of 30-inch spruce tree; nail marked "3082"	3,083.28
Big Meadows, 1.8 miles southwest of, 3 feet south of trail, in root of 16-inch hemlock tree; nail marked "3054"	3,055.42
Big Meadows, 1.25 miles southwest of, 3 feet north of trail, 70 feet north of Trail Creek, in root of spruce tree 24 inches in diameter; nail marked "3025"	3,026.79
Big Meadows, 0.8 mile southwest of, 100 feet southeast of fork of Lake View and Cœur d'Alene trails, 3 feet north of trail, 300 feet northwest of mouth of Bear Creek, in root of 10-inch balsam fir tree; nail marked "3021"	3,022.00

Mouth of Cascade Canyon to point 2.5 miles northwest of Wright's ranch (spur line).

Wright's ranch, 400 feet west of, 10 feet north of river, in root of 24-inch white pine tree; nail marked "2856"	2,855.94
Burnt Cabin Creek, 55 feet northeast of mouth, 0.8 mile west of Wright's ranch, on large protruding rock 3 feet above water; cross marked "2874"	2,874.99
Wright's ranch ,1.25 miles northwest of, 1,600 feet northwest of mouth of Burnt Cabin Creek, 10 feet south of river, in root of white fir tree; nail marked "2882"	2,883.55
Wright's ranch, 2 miles northwest of, 12 feet east of river, 15 feet west of trail, in root of 36-inch spruce tree; nail marked "2902"	2,903.05
Wright's ranch, 2.5 miles northwest of, 200 feet west of trail, below dense willow swamp, south bank of river at sharp bend, in root of 20-inch spruce tree; nail marked "2916"	2,916.99

Mouth of Bear Creek along trail via Magees to mouth of East Fork of Cœur d'Alene River, thence down river to mouth of Little North Fork.

Big Meadows, 0.2 mile west of, 300 feet west of mouth of Teepee Creek, on steep hillside, 25 feet south of trail, in root of red fir tree 18 inches in diameter; nail marked "3138"	3,139.06
Magee's ranch, 0.25 mile west of, 260 feet north of mouth of Teepee Creek, 3 feet south of trail, in root of 22-inch spruce tree; nail marked "2997"	2,998.19
C. Magee's cabin, 120 feet south of, 300 feet north of Trail Creek, 60 feet north of trail, on gravel knoll in open meadow; iron post stamped "2984 S"	2,985.289
C. Magee's cabin, 1 mile northeast of, 50 feet northwest of Trail Creek, 6 feet southeast of trail, in root of 8-inch white fir tree; nail marked "2957"	2,958.61

	Feet.
C. Magee's ranch, 2 miles northeast of, 70 feet south of trail, bank of Trail Creek, on projecting rock 3 feet above water; cross marked "2926"	2,926.96
Scott's cabin, 150 feet northeast of, 50 feet west of Trail Creek, 20 feet west of trail, in small meadow, in root of balsam fir tree in clump of three; nail marked "2919"	2,920.12
T. S. Vickere's cabin, 220 feet northwest of, 20 feet southwest of Trail Creek, 8 feet east of trail, in root of spruce tree forking in two; nail marked "2903"	2,904.70
Independence Creek, 200 feet north of mouth, 35 feet east of creek, 7 feet north of trail, 5 feet south of 36-inch cottonwood tree, on small gravel knoll; iron post stamped "2894"	2,895.168
Independence Creek, 1 mile northeast of mouth, 30 feet southwest of river, 15 feet southeast of an old cabin, in root of 20-inch white pine tree; nail marked "2874"	2,874.93
Independence Creek, 2.25 miles northeast of mouth, 30 feet north of river, in root of 35-inch white pine tree; nail marked "2847"	2,848.41
East Fork of Cœur d'Alene River, 1 mile northwest of mouth, 0.5 mile southeast of Peterson's cabin, north bank of river, in root of 12-inch cottonwood tree; nail marked "2813"	2,813.68
East Fork of Cœur d'Alene River, 240 feet southeast of mouth, 30 feet south of north fork of river, 40 feet west of Miss Otterson's cabin; iron post stamped "2796 S"	2,797.072
East Fork of Cœur d'Alene River, 1.25 miles southeast of mouth of, on north bank of river opposite limestone cliff, in root of 18-inch cottonwood tree; nail marked "2768"	2,769.56
East Fork of Cœur d'Alene River, 2.25 miles southeast of mouth of, on east bank of river, on large square rock sloping into river and 3 feet above surface of water; cross marked "2748"	2,749.32
East Fork of Cœur d'Alene River, 3.25 miles southeast of mouth, on east bank of river, opposite large riffle, in root of 18-inch cottonwood tree; nail marked "2731"	2,731.70
East Fork of Cœur d'Alene River, 4.25 miles southeast of mouth, 30 feet south of river, 90 feet northeast of cabin, in root of 10-inch willow tree; nail marked "2714"	2,715.14
East Fork of Cœur d'Alene River, 5 miles southeast of mouth, on south bank of river, 4 feet above water, on shelving rock protruding from a high cliff, 600 feet west of L. Sherman's cabin; cross marked "2701"	2,702.32
Big Henk's meadow, 0.5 mile southeast of, at sharp bend in river, 6 feet above water, on large projecting rock; cross marked "2674"	2,675.07
Big Henk's meadow, 1.25 miles southeast of, 350 feet south of mouth of creek, at base of cliff 200 feet high, 3 feet north of white pine tree 24 inches in diameter, on top of rock; cross marked "2661"	2,661.94
Big Henk's meadow, 2.5 miles southeast of, upper end of Long Pool, at base of cliff, 25 feet above water, on shelving rock; cross marked "2640"	2,641.21
Big Pool, 60 feet north of, 220 feet southeast of an old cabin, 7 feet northeast of hemlock tree 30 inches in diameter; iron post stamped "2636 S"	2,636.840
Big Pool, 1.25 miles southeast of, 300 feet east of mouth of creek, opposite old cabin, 3 feet above water, on highest point of large rock projecting above water; cross marked "2607"	2,607.77
Big Pool, 2.5 miles southeast of, on east bank of river, 60 feet west of foot of high cliff, 3 feet above water, on highest point of large rock; cross marked "2587"	2,587.59
Big Pool, 3 miles southeast of, on west bank of river, at base of cliff, 6 feet above water, on top of large rock; cross marked "2579"	2,580.27

	Feet.
Big Pool, 4 miles southeast of, west bank of river, opposite high cliff, in root of 30-inch cottonwood tree; nail marked "2564"	2, 564. 77
Kit Price's prairie, southeast end of, 40 feet west of river, in root of 48-inch twin cottonwood tree; nail marked "2535"	2, 536. 11
Kit Price's prairie, 1 mile southeast of, near middle of river, 3 feet above water, on large rock; cross marked "2519"	2, 519. 87
Kit Price's prairie, 2 miles southeast of, on west bank of river, in root of 30-inch cottonwood tree; nail marked "2506"	2, 506. 28
Kit Price's prairie, 3 miles southeast of, 0.5 mile north of mouth of Big Creek, on east bank of river, in root of 24-inch cottonwood tree; nail marked "2492"	2, 492. 99
Big Creek, 1 mile southeast of mouth, on north bank of river, in root of cottonwood tree forking in three; nail marked "2474"	2, 475. 06
Big Creek, 1.25 miles southeast of mouth, on south bank of river, opposite jagged cliff, on very large rectangular rock sloping down to water, 1 foot above high water mark; aluminum tablet stamped "2472 S"; sunk into rock	2, 472. 314
Copper Bell mine, 200 feet east of mouth of tunnel, 50 feet east of location tunnel, on south bank of river, 7 feet above water, on projecting point of cliff; cross marked "2455"	2, 456. 11
Copper Bell mine, 1.25 miles south of, 2.8 miles northeast of mouth of Prichard Creek, 5 feet above water, south bank of river, on top of large rock; cross marked "2438"	2, 438. 32
Prichard Creek, 2 miles northeast of mouth, 1,600 feet west of Whipple's cabin, on south bank of river, in root of 18-inch cottonwood tree; nail marked "2425"	2, 425. 88
Prichard Creek, 0.8 mile northeast of mouth, on south bank of river, opposite rocky point, in root of 24-inch twin cottonwood tree; nail marked "2409"	2, 409. 74
Prichard Creek, 0.9 mile southwest of mouth, on east bank of river, 400 feet northwest of old cabin, opposite burned steep rocky slope, in root of 12-inch cottonwood tree; nail marked "2387"	2, 387. 56
North Fork of Cœur d'Alene River, east side of, 200 feet north of Delta road, at foot of cliff, 7 feet above water; aluminum tablet stamped "2370 S"	2, 372. 469
North Fork of Cœur d' Alene River, 30 feet east of, 160 feet north of Delta road, on narrow rock projecting from cliff, 11 feet above water; aluminum tablet stamped "2376 S"	2, 376. 238
Beaver Creek, 3.3 miles west of, on south side of river, 800 feet north of cliff, in root of 30-inch cedar tree; nail marked "2325"	2, 327. 24
Big Jam, 1.6 miles southwest of, on south bank of river, opposite high craggy cliff, at edge of burn, in root of 10-inch cedar tree; nail marked "2280"	2, 280. 08
Castle Rock, 50 feet east of west end, flat rock sloping toward cliff; highest part; marked "2256"	2, 257. 61
Steamboat Rock, 200 feet east of, 60 feet from west end of cliff, east side of Steamboat Creek at mouth; aluminum tablet stamped "2248 S"	2, 249. 44

Mouth of Bear Creek via Lake View to Pend Oreille Lake.[1]

Bear Creek, 0.8 mile north of mouth, 40 feet east of Bear Creek, 10 feet west of trail, in root of 20-inch spruce tree; nail marked "3098"	3, 099. 46
Bear Creek, 1.25 miles north of mouth, 2 feet west of track, in root of black stump; nail marked "3151"	3, 152. 78

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[1] The closure error in this circuit is excessive.

	Feet.
Bear Creek, 2 miles north of mouth, 30 feet east of Bear Creek, 4 feet east of trail, in root of lone white pine tree 36 inches in diameter; nail marked "3280"	3,281.52
Bear Creek, 2.3 miles north of mouth, on steep open incline, 20 feet northeast of trail, in root of 10-inch black pine tree; nail marked "3575"	3,576.55
Bear Creek, 2.5 miles north of mouth, on steep open incline, sloping toward the south, 6 feet west of trail, in root of 24-inch line white pine tree; nail marked "3974"	3,975.44
Bear Creek, 2.8 miles north of mouth, on steep open incline, sloping toward south, 25 feet east of trail, in root of 20-inch red fir tree; nail marked "4440"	4,441.53
Bear Creek, 2.9 miles north of mouth, on steep open incline, sloping toward the south, 20 feet east of trail, in root of 9-inch fir tree; nail marked "4684"	4,685.03
Bear Creek, 3 miles north of mouth, on top of first summit on trail between mouth of Bear Creek and Lake View, 3 feet north of trail, in root of 24-inch red fir tree; nail marked "4734"	4,735.53
Bear Creek, 3 miles north of mouth, on top of first summit between mouth of Bear Creek and Lake View, 3 feet below apex of rocky point, in flat black shale rock; aluminum tablet stamped "4858 S"	4,859.519
Bear Creek, 3.25 miles northwest of mouth, on top of ridge, where trail makes first big drop toward Independence Creek, 5 feet west of trail, in root of 9-inch balsam fir tree; nail marked "4838"	4,839.75
Bear Creek, 3.5 miles northwest of mouth, 1.8 miles south of Independence Creek, 3 feet east of trail, in root of 24-inch tamarack tree; nail marked "4522"	4,523.21
Bear Creek, 3.6 miles northwest of mouth, 1.7 miles south of Independence Creek, at foot of steep slope, in root of 30-inch fir tree; nail marked "4364"	4,365.71
Bear Creek, 4 miles northwest of mouth, 1.5 miles south of Independence Creek, 30 feet west of trail, on west slope of small grassy knoll, in root of balsam fir tree forking in two; nail marked "4320"	4,321.39
Bear Creek, 4.25 miles northwest of mouth, 1.25 miles south of Independence Creek, on high bushy knoll, in root of 12-inch white fir tree; nail marked "4515"	4,516.27
Bear Creek, 4.4 miles northwest of mouth, 1 mile south of Independence Creek, on steep brushy incline, sloping toward west, 30 feet southwest of trail, in root of 10-inch hemlock tree; nail marked "4200"	4,201.41
Independence Creek, 0.25 mile south of, on steep wooded incline, sloping down to creek, 6 feet north of trail, in root of 30-inch white pine tree; nail marked "3691"	3,692.46
Independence Creek, 0.2 mile south of, on steep wooded point sloping down to creek, 20 feet north of trail, in root of 20-inch hemlock tree; nail marked "3576"	3,577.04
Mrs. Lovell's cabin, 6 feet southwest of, 120 feet south of Independence Creek, 5 feet north of trail, 11 miles southeast of Lake View; iron post stamped "3275 S"	3,276.557
Mrs. Lovell's cabin, 0.25 mile west of, 400 feet north of Independence Creek, 6 feet north of trail, on steep open point sloping south, in root of 10-inch fir tree; nail marked "3429"	3,430.10
Mrs. Lovell's cabin, 0.4 mile west of, 500 feet north of Independence Creek, at beginning of second switchback on trail, in root of 9-inch fir tree; nail marked "3645"	3,646.61
Independence and Bear Creek trails, 120 feet west of intersection of, on high burned divide, 12 feet north of Lake View trail, in root of 12-inch tamarack tree: nail marked "4280"	4,281.22

	Feet.
Weber mine, 1.6 miles southeast of, 150 feet south of summit of divide, 0.5 mile north of Independence Creek, 12 feet south of trail, in root of 30-inch tamarack tree; nail marked "4908"	4,909.55
Weber mine, 1.5 miles southeast of, on top of divide, burned ridge, 3 feet north of trail, in root of 24-inch tamarack tree; nail marked "4983"	4,984.75
Lake View, 6 miles southeast of, 1 mile southeast of Weber mine, at head of graded road, on lowest part of divide; iron post stamped "4602 S"	4,604.542
Weber mine, 120 feet southwest of entrance, 30 feet northwest of road, in root of large black stump; nail marked "3606"	3,607.97
Conjecture mill, 4 miles southeast of Lake View, in top of stringer in southwest corner of mill; nail marked "3164"	3,165.49
Lake View, 3.5 miles southeast of, 10 feet west of road, at foot of long hill, in root of black tree; nail marked "2764"	2,764.96
Lake View, 1.8 miles southeast of, on top of hill, 7 feet east of county road, in root of 9-inch jack pine tree; nail marked "2695"	2,697.12
Lake View, corner of South Street and Rus Avenue, 1 foot north of southwest corner lot 8, block 6, 75 feet southeast of post-office; iron post stamped "2269 S"	2,269.824
Pend Oreille Lake, 100 feet south of, 1,500 feet north of Lake View, 50 feet east of North Gold Creek, in root of 36-inch twin cottonwood tree; nail marked "2064"	2,065.60
Pend Oreille Lake, 60 feet east of mouth of North Gold Creek, at water surface; bridge spike	2,051.45
Pend Oreille Lake, 60 feet east of mouth of North Gold Creek; surface of water, Sept. 9 and Sept. 12, 1905	2,051.4

Kingston via Oregon-Washington Railroad & Navigation Co. tracks to Wallace.

Kellogg, 200 feet southeast of station, 5 feet west of northwest corner of Hotel McKinniss; iron post stamped "2305 S"	2,305.720
Osburn, 300 feet northwest of hotel, 3 feet north of north corner of grocery store, on west side of Mullan Avenue; iron post stamped "2521 S"	2,521.874
Wallace, 1 foot north of schoolhouse, 1 foot east of wall, 7 feet south of northeast corner; iron post stamped "2728 S"	2,728.506

Osburn via Beaver and Delta to Murray.

Beaver, 6 feet north of northeast corner of station house, 3 feet east of fence, 5 feet north of porch; iron post stamped "2785 S"	2,785.385
Murray and Delta, summit of mountain between, 25 feet north of road; iron post stamped "3321 S"	3,321.819
Murray, at intersection of Main and Second streets, 6 feet west of southwest corner of printing office; iron post stamped "2772 S"	2,772.435

Murray via Eagle and east fork of Eagle Creek to point 4 miles east of Eagle (single spur line).

Murray, 1.7 miles northwest of, 15 feet south of old flume, 5 feet south of road, in poplar tree; spike	2,654.028
Murray, 2.7 miles northwest of, in tree 15 feet east of road; spike	2,601.518
Eagle, 20 feet north of cabin, 30 feet east of road; iron post stamped "2546 S"	2,547.088
Eagle, 120 feet north or road, 350 feet west of white house, in fir tree; spike	2,549.896
Eagle, 1 mile east of, 450 feet southeast of house, south of road, in spruce tree; spike	2,619.773
Eagle, 1.2 miles east of, 50 feet east of forks of road, in spruce tree; spike	2,626.716
Eagle, 4 miles east of, 400 feet northeast of branches of creek, north of road, at base of cliff, in quartz rock; copper bolt stamped "2892 S"	2.892.674

	Feet.
Delta, Murray, and Little North Fork roads, intersection of, 210 feet east of, 40 feet south of creek at bend in road, in root of pine tree 12 inches in diameter; nail	2, 532. 768
Halzandorf's ranch, 780 feet north of, forks of roads, east side of road, in root of cedar tree; nail	2, 230. 457

Wallace east along Northern Pacific Railway to Idaho-Montana boundary line.

Mullan, 15 feet west of station, at corner of sidewalk, at base of Northern Pacific Railway station steps; iron post stamped "3244 S"	3, 244. 855
Lookout, summit of Bitterroot Mountain, Mont., 250 feet south of Montana-Idaha State line, 30 feet west of station; iron post stamped "4727 S".	4, 727. 268

Wallace east via Gem and Burke to Glidden Pass.

Granite, opposite Granite mill, 10 feet north of Canyon Creek, in root of pine stump; spike	3, 168. 202
Gem, 725 feet east of Granite mill, 6 feet west of house, on fence line, 45 feet north of Northern Pacific Railway, 20 feet north of wagon road; aluminum bolt in granite bowlder 5 by 5 by 4 feet, stamped "3197 S"	3, 197. 045
Burke, 15 feet north of Northern Pacific Railway track, 15 feet east of house, 17 feet northeast of telegraph pole, 60 feet west of road crossing, 10 feet north of wagon road, 180 feet west of station, in rock at base of cliff; aluminum tablet stamped "3736 S"	3, 736. 657
Burke, in front of station; top of rail	3, 740. 9
Burke, 1.6 miles northeast of, south of Tiger-Poorman electric station, 18 feet north of wagon road, in spruce tree; spike	4, 100. 33
Burke, 3 miles east of, 100 feet north of flume, 1 foot south of road, in root of fir tree 4 inches in diameter; spike	4, 783. 67
Glidden Pass, 15 feet east of road, summit of Bitterroot Mountains, in white limestone pillar 5 by 5 inches at top, 2.3 feet high, projecting 4 inches above ground; aluminum tablet stamped "5768"	5, 768. 296

Murray east via Raven to Thompson Pass, Idaho-Montana State line.

Murray, 1 mile east of, 2 feet west of road, in root of pine stump; spike	2, 911. 337
Raven, 100 feet south of old sawmill, at north end of Burke trail, at mouth of Granite Creek, in bowlder 6 inches above ground at base of stump; aluminum tablet stamped "3060 S"	3, 060. 761
Raven, 1.1 miles east of, 20 feet south of road, in root of pine tree 8 inches in diameter; spike	3, 258. 155
Sullivan, 1 mile east of, 2 feet north of road, 35 feet northeast of blazed tree on south side of road, in sandstone; cross	3, 908. 110
Summit of Bitterroot Mountain, 25 feet northeast of road, 25 feet southeast of flume; iron post stamped "4862 S"	4, 862. 292

Burke along trail to Raven.

Burke, 1 mile north of, 2 feet south of trail at switchback, in root of spruce tree 5 inches in diameter; spike	4, 632. 70
Summit, 6 feet east of trail; iron post stamped "5839 S"	5, 839. 468

Beaver via Dobson Pass to Wallace.

Beaver, 2 miles southeast of, 12 feet east of road, in pine tree 1 foot in diameter; spike	3, 502. 23
Beaver, 3 miles southeast of, 6 feet east of road, in spruce tree 2 feet in diameter; spike	3, 948. 90
Dobson Pass, 12 feet south of road; iron post stamped "4179 S"	4, 179. 934
Dobson Pass, 1.1 miles southeast of, 10 feet west of road, in root of tamarack tree 1 foot 6 inches in diameter; spike	3, 802. 13

Kellogg via county road to Wardner.

	Feet.
Kellogg, 0.7 mile south of, 20 feet southeast of telephone pole, west of road, in cedar stump; nail	2, 521. 353
Wardner, in foundation of Empire State-Idaho Mining & Developing Co. compressor under cylinder head of high pressure air cylinder; aluminum tablet stamped "2880 S"	2, 880. 142
Wardner, Bunker Hill & Sullivan machine shop, 300 feet north of, on rock west of road; cross	2, 960. 301

Delta along wagon road and trail down North Fork of Cœur d'Alene River to Kingston.

Delta, 1 mile northwest of, 150 feet southeast of house, on west side of bend in road, in root of poplar tree; nail	2, 471. 035
Delta, 2 miles northeast of, east side of road, in root of dead fir tree; nail	2, 433. 166
North Fork of Cœur d'Alene River, at intersection of road with river, in a twin cedar; nail	2, 369. 643
North Fork of Cœur d'Alene River, east side of, 200 feet north of Delta road, at foot of cliff, 7 feet above river; aluminum tablet stamped "2370 S"	2, 371. 772
Morrison's mine, on rock at entrance; cross	2, 332. 901
Big Jam, 450 feet east of, sunk into a flat rock sloping into river, 3 feet above surface, on south side; aluminum tablet stamped "2297 S"	2, 298. 950
Big Jam, 1 mile west of, 1,000 feet southwest of junction of old and northwest channel of river, on south side; cross on rock 3 feet above surface of water.	2, 287. 046

Bonners Ferry, Calispell, Pend Oreille, and Sandpoint quadrangles.

BONNER AND KOOTENAI COUNTIES.

The elevations in the following list were determined by a double primary level line from Tacoma and by other primary lines. The list includes descriptions taken from the appendix to the Twentieth Annual Report of the Geological Survey, pages 471 to 474 and pages 521 and 522, inclusive, with readjusted elevations.

The leveling was done in the Sandpoint quadrangle in 1897 by Charles Harlow, jr., in 1898 by W. R. Prowell and H. S. Crowe; in the Pend Oreille quadrangle in 1898 by H. S. Crowe, and in 1903 by G. H. Kendall; in the Calispell quadrangle in 1898 by Prowell; and in the Bonners Ferry quadrangle in 1904 by M. S. Bright, J. G. Hefty, and G. H. Kendall.

SANDPOINT QUADRANGLE.

Granite along Northern Pacific Railway to Sandpoint.

	Feet.
Granite, in front of station; top of rail	2, 260. 7
Granite, 45 feet west of west edge of station platform, 20 feet south of center of track, near telegraph pole; iron post stamped "2262 T"	2, 262. 666
Milepost "W.213, H.33," 19 feet west of, 28 feet west of center of track; iron post stamped "2251 T"	2, 251. 252
Cocolalla, in front of section house; base of rail	2, 220. 3
Milepost "W.218, H.28," 250 feet northeast of, 18 feet north of railroad, southeast of whistling post; iron post stamped "2226 T"	2, 226. 419
Algoma siding; top of east head block	2, 177. 4
Milepost "W.224, H.22," 390 feet southeast of, 25 feet south of railroad track, at west end of cut; iron post stamped "2167 T"	2, 167. 277
Sandpoint, in front of station; top of rail	2, 086. 4

	Feet.
Sandpoint, 83 feet southwest of Northern Pacific station, 6 feet north of Butler & Culver warehouse, west side of street, at edge of sidewalk, 62 feet west of main track; iron post stamped "2087 T," restamped "2085" when reset	2,085.107
Sandpoint, T. 57 N., R. 2 W., 32 feet northeast of Spokane International Railway section house; iron post stamped "2117 T"	2,117.498
Sandpoint, in front of telegraph office of Northern Pacific Railway station; top of rail	2,119.4

Albane Falls east and north along Great Northern Railway to 3 miles northeast of Colburn.

Priest River, in front of station; top of rail	2,080.4
Priest River, 75 feet south by 167 feet east of water tank, 75 feet south of south rail; iron post stamped "2077 P. R."	2,082.394
Markham, in southeast corner of sec. 20, T. 56 N., R. 3 W., 60 feet from front door of post office, inside yard; iron post stamped "2088 P. R."	2,093.580
T. 57 N., R. 3 W., SW. ¼ sec. 26, in center of C. Carr's front yard, 100 feet from house; iron post stamped "2087 P. R."	2,091.959
Colburn, 1.2 miles north of section house, northwest corner of T. 58 N., R. 1 W., 1,700 feet northwest of railway track; iron post stamped "2127 P. R."	2,133.432

Elmira siding to corner of Tps. 59 and 60 N., Rs. 1 and 2 W.

Elmira, 3.2 miles west of, northwest corner of T. 59 N., R. 1 W.; aluminum tablet stamped "4031 P. R."	4,037.680

Cary Ferry south and west to Medler Lake.

T. 55 N., R. 4 W., sec. 33, 100 feet from Vogler's house, at north gatepost; iron post stamped "2222 P. R."	2,227.625
T. 54 N., Rs. 4 and 5 W., quarter corner between secs. 24 and 19, 900 feet south of road; iron post stamped "2286 P. R."	2,291.060

Priest River northwest along road up West Branch.

Terrells Falls, near east side of sec. 16, T. 57 N., R. 5 W., at east end of bridge across West Branch of Priest River, just below falls, about 600 feet east of Terrell's house; iron post stamped "2289 P. R."	2,294.785
T. 58 N., R. 5 W., SW. ¼ sec. 27, at lower end of S. H. Moor's ranch, at west side and north end of bridge across small stream, about 400 feet from section corner; iron post stamped "2411 P. R."	2,416.192

Priest River north along road to Priest Lake.

Tps. 56 and 57 N., R. 4 W., on line between, 5 yards west of road; iron post stamped "2371"	2,376.053
Tps. 57 and 58 N., R. 4 W., on line between, 5 yards west of road; iron post stamped "2405"	2,410.730
Tps. 58 and 59 N., R. 4 W., on line between, 4 yards west of road; iron post stamped "2543"	2,548.002
Coolin, northwest of northwest corner of fence, 15 yards from edge of lake; iron post stamped "2442"	2,447.102
Priest Lake; surface of water, September, 1898	2,439.4
Coolin, Aug. 29, 1905	2,438.9
Coolin, 200 yards south of, triangulation station; iron post	2,445.235

Coolin to corner of Tps. 59 and 60 N., Rs. 4 and 5 W.

Coolin, 2.5 miles northwest of, northwest corner of T. 59 N., R. 4 W., in rock; aluminum tablet stamped "2760"	2,765.854

Coolin to corner of Tps. 59 and 60 N., Rs. 3 and 4 W.

	Feet.
Coolin, 3.8 miles northeast of, northwest corner of T. 59 N., R. 3 W., in rock; aluminum tablet stamped "3852 P. R."	3, 857. 716

Priest Lake road east to southwest corner of T. 58 N., R. 3 W.

T. 58 N., R. 3 W., southwest corner of, in rock; aluminum tablet stamped "3491 P. R."	3, 496. 581

Spur line from Northern Pacific Railway to northwest corner of T. 56 N., R. 1 W.

T. 56 N., R. 1 W., northwest corner of, 5.5 miles from Sandpoint and 1.8 miles east of Northern Pacific Railway track; iron post stamped "3376"	3, 381. 801

Spur line from Northern Pacific Railway to northwest corner of T. 54 N., R. 2 W.

T. 54 N., R. 2 W., northwest corner of, 0.6 mile east of Northern Pacific Railway track; iron post stamped "2289"	2, 294. 004

PEND OREILLE QUADRANGLE.

Sandpoint along Northern Pacific Railway to Idaho-Montana boundary line.

Kootenai, 60 feet north of post office door; iron post stamped "2117 T"	2, 116. 840
Oden siding; top of east head block	2, 075. 2
Milepost "W. 240, H. 6," 300 feet east of, on knoll, 30 feet south of center of track; iron post stamped "2079 T"	2, 078. 951
Hope, in front of telegraph office; top of rail	2, 078. 2
Hope, 70 feet west of station, in lot between hotel and station, 20 feet north of center of track; iron post stamped "2080 T"	2, 079. 692
Thornton, 225 feet southeast of station, east end of siding, 45 feet south of track at east end of cut; iron post stamped "2103 T"	2, 102. 546
Clark Fork, 90 feet east of milepost "H. 10, HLNA 288," at east corner of fence of railroad section house; iron post stamped "2081 T"	2, 081. 141
Clark Fork, second crossing; surface of water	2, 062. 5
Milepost "H. 15, HLNA 283," 0.2 mile east of, 15 feet north of track, opposite spur for loading logs; iron post stamped "2101 T"	2, 100. 403
Cabinet, in front of section house; top of rail	2, 186. 4
Idaho-Montana boundary line, at signboard 15 feet north of track; iron post stamped "2212 T"	2, 212. 182

Point near Elmira north via Great Northern Railway.

Elmira, 1 mile north of, 50 feet east of track, 30 feet southeast of road crossing; iron post	2, 148. 539

BONNERS FERRY QUADRANGLE.

Point near McCarthy siding north along Great Northern Railway to Bonners Ferry.

Milepost 1383, 135 feet south of, 40 feet southeast of track, in slope; iron post	2, 104. 270
Naples, 1,000 feet south of station, opposite milepost 1380, 65 feet east of track, 700 feet south of water tank; iron post	2, 018. 337
Naples, in northeast corner of northeast foundation stone under water tank; cross	2, 028. 212
Bridge 211, 1,000 feet north of, 300 feet northwest of cut, 120 feet west of track, at first telegraph pole south of milepost 1377; iron post	1, 955. 481
Milepost 1374, opposite, 300 feet northeast of tunnel 10, 150 feet west of track on old roadbed, 100 feet southwest of road at Dunn's ranch; iron post	1, 834. 911
Moravia, in front of station sign; top of west rail	1, 849. 1
Mirror Lake; surface of water, July 13, 1904	1, 763. 9

	Feet.
Bonners Ferry, 2.5 miles southwest of, opposite milepost 1371, 60 feet west of track, on east shore of Mirror Lake; iron post	1,766.663
Bonners Ferry, in front of Great Northern Railway station; top of rail	1,778.8

Bonners Ferry via Kootenai Valley Railway to international boundary line.

Bonners Ferry, 0.5 mile east of, 30 feet northeast of railroad track where it enters a cut, south corner of town lot 18, block 1, near residence of Benj. Morrow; iron post	1,786.594
Bonners Ferry, near Kootenai River, under bridge; surface of water, Mar. 28, 1904	1,748
Bonners Ferry, 2.4 miles north of, at edge of right of way, 30 feet east of track, at north edge of small cleared flat at mouth of draw on sharp curve of track; iron post	1,792.204
Bonners Ferry, 6 miles north of, 30 feet east of track, 150 feet north of Wrider's cabin, at fence; iron post	1,789.242
Bonners Ferry, 9 miles north of Empy's house, at road crossing, 30 feet east of track, at edge of wagon road and at foot of rocky bank; iron post	1,788.097
Copeland, 5 miles south of, McRay's ranch, in front of house, 20 feet east of track, 50 feet north of small creek; iron post	1,789.484
Copeland, 2.4 miles south of, 150 feet south of milepost 14, 30 feet east of track; iron post	1,799.751
Copeland, 450 feet north of Cole's store, 40 feet east of track; iron post	1,788.474
Port Hill, 2.8 miles south of, on bank 30 feet east of track, 170 feet north of trestle 10; iron post	1,783.838
Port Hill, in front of station; top of rail	1,781.7
Port Hill, international boundary line, 4 feet west of original stone monument marking boundary, 60 feet east of railroad, east of Kootenai River; iron post	1,797.277

CALISPELL QUADRANGLE.

Newport south to Medler Lake.

Newport, Washington-Idaho State line, corner of secs. 24 and 25, T. 56 N., R. 6 W.; iron post stamped "2128 P. R."	2,133.281
T. 54 N., R. 5 W., northwest corner of; iron post stamped "2326 P. R."	2,331.843

Priest Lake quadrangle.

KOOTENAI COUNTY.

The following elevations are based on that of an iron post stamped "2442" near the edge of Priest Lake at Coolin, the accepted elevation of which is 2,447.102 feet. Water leveling was used in determining elevations at other points on the lake, and from these only single spur primary level lines were run and the elevations are therefore unchecked. The Coolin elevation is determined in part through primary circuits and in part by a single spur line in the Sandpoint quadrangle from the double line from Tacoma, as published on page 521 of the appendix to the Twentieth Annual Report of the Geological Survey.

The leveling was done in 1905 by A. L. Glover.

PRIEST LAKE QUADRANGLE.

Bench marks near Reeder Creek and Bear Creek.

	Feet.
Priest Lake; surface of water, August 31, 1905	2,438.8
Reeder Creek, about 1,000 feet north of mouth, 90 feet west of end of old Reeder Creek trail, 130 feet west of water's edge on top of first terrace, 7 feet north of trail, 6 feet northwest of stump 10 inches in diameter and 50 feet high, 300 feet north of only live fir and cedar trees in the vicinity; iron post stamped "2468"	2,467.999
Bear Creek Bay, south side of, opposite mouth of Granite Creek, about halfway to end of point from mouth of Bear Creek, on east side of lake, at old camp, 50 feet south of water's edge, about middle of small sandy stretch of beach rocky at both ends, 10 feet north of blazed and marked 24-inch pine tree; iron post stamped "2447"	2,446.990

Thoroughfare (watercourse between Lower and Upper Priest lakes) north along Continental mine trail to Continental mine.

Thoroughfare, on east bank, at south end, 200 feet from water opposite entrance, between two large blazed tamarack trees about 18 inches in diameter, one of which has top broken off—the only large trees on the end of bar—10 feet from each tree; iron post stamped "2447"	2,447.107
Thoroughfare, 0.7 mile from south end of, on east bank, 15 feet from water, in root of 18-inch blazed tamarack tree; spike marked "2447"	2,447.08
Thoroughfare, 1.3 miles from south end of, north side of Caribou Creek, on end of point between entrance of Caribou Creek into Thoroughfare, 30 feet east of Thoroughfare, 15 feet north of water's edge in Caribou Creek, in root of 10-inch pine tree; spike marked "2450"	2,450.01
Thoroughfare, 2 miles from south end of, 40 feet west of water's edge, at foot of 30-inch cedar tree, in small stump 3 inches high and 4 inches in diameter, near tree blazed and marked "2455"; spike	2,455.41
Thoroughfare, north end of, at south end of upper lake, 8 feet east of blazed and marked spruce tree 18 inches in diameter, 50 feet north of 24-inch blazed pine tree, 75 feet east of water's edge, 20 feet east of edge of sand beach, 150 feet northeast of end of sand point; iron post stamped "2447"	2,447.004
Upper Priest Lake; surface of water September 2, 1905	2,438.95
Upper Priest Lake, at north end on east side, where the Continental mine trail reaches the shore of the lake, 50 feet east of water, 5 feet west of trail, 15 feet east of 10-inch cottonwood tree blazed and marked "2447"; iron post stamped "2447"	2,447.025
Continental mine, 10.3 miles south of, 1 foot east of trail, near dead 48-inch cedar tree, in stump; nail marked "2454"	2,453.68
Continental mine, 9.9 miles south of, 1 foot west of trail, in root of 24-inch cedar tree; spike marked "2489"	2,488.78
Continental mine, 9.4 miles south of, 10 feet west of trail, in root of 18-inch cedar tree; nail marked "2512"	2,511.81
Continental mine, 8.9 miles south of, 12 feet east of trail, in root of 24-inch hemlock tree; nail marked "2487"	2,487.22
Continental mine, 8.2 miles south of, 20 feet east of trail, in root of dead 12-inch stump 30 feet high; nail marked "2594"	2,594.30
Continental mine, 7.8 miles south of, 4 feet west of trail, in root of 24-inch cedar tree; nail marked "2620"	2,620.36

	Feet.
Continental mine, 7.4 miles south of, 3 feet east of trail, in root of 30-inch hemlock tree; nail marked "2638"	2,638.27
Continental mine, 6.8 miles south of, 15 feet east of trail, in root of 30-inch cedar tree; nail marked "2664"	2,664.31
Continental mine, 6.5 miles south of, 4 feet west of trail, in root of 12-inch hemlock tree; nail marked "2676"	2,676.34
Continental mine, 5.8 miles south of, 4 feet east of trail, in root of 36-inch cedar tree; nail marked "2705"	2,704.82
Continental mine, 5.1 miles south of, short distance east of mouth of Cedar Creek, 1 foot above and 2 feet east of trail to Continental mine, 10 feet northwest of blazed and marked 18-inch cedar tree 4 feet west of trail, on top of small hill over the end of which the trail passes, in 3 foot granite rock; aluminum tablet stamped "2736"	2,735.990
Continental mine, 4.8 miles south of, west edge of trail, in root of 18-inch hemlock tree; nail marked "2873"	2,872.84
Continental mine, 4.4 miles south of, 6 feet east of trail, in root of 30-inch cedar tree; nail marked "2913"	2,913.15
Continental mine, 4.1 miles south of, 15 feet east of trail, in root of 30-inch hemlock tree; nail marked "2950"	2,950.44
Continental mine, 3.7 miles south of, 15 feet southeast of trail, about 200 yards south of first cabin on Cedar Creek where trail crosses, in root of 42-inch hemlock tree; nail marked "3079"	3,079.23
Continental mine, 3.4 miles south of; surface of water in Cedar Creek at trail crossing, September 17, 1905; elevation marked on 24-inch cedar log across stream 4 feet above water, 30 feet northeast of trail crossing and 75 feet south of cabin	3,089.7
Continental mine, 3.4 miles south of, 100 feet north of creek, 15 feet west of northwest corner of cabin at trail crossing Cedar Creek, 1 foot east of trail, in root of 48-inch cedar tree; nail marked "3115"	3,114.77
Continental mine, 3 miles south of, 2 feet south of second cabin on trail, 7 feet east of southeast corner of house, side of house marked "3381"; marked point on rock	3,381.22
Continental mine, 2.6 miles south of, south edge of trail, on top of first high point crossed by trail, above second cabin on trail, in root of 4-inch birch tree; nail marked "3705"	3,705.44
Continental mine, 2.2 miles south of, 10 feet north of trail, 50 feet northwest of small creek just before reaching Cedar Creek, where trail crosses at lowest place trail strikes, in root of 30-inch cedar tree; nail marked "3693"	3,692.87
Continental mine, 1.8 miles south of, 200 feet north of Cedar Creek, 20 feet south of trail, 2 feet southeast of stream 1 foot wide, 100 feet south of large stream, both crossed by trail which then runs parallel to Cedar Creek, in root of 48-inch hemlock tree; nail marked "3920"	3,919.59
Continental mine, 1.77 miles south of, on trail, 1,000 feet south third cabin up trail, near 12-inch hemlock tree 5 feet north of trail, in a 5-foot granite rock 2 feet above ground; aluminum tablet stamped "3932"	3,932.065
Continental mine, 1.6 miles south of, east edge of trail, near 24-inch dead burnt fir tree marked "4058," 400 feet south of cabin; marked point on rock	4,058.07
Continental mine, 1.5 miles south of, at southeast corner of cabin, in log, nail; marked on cabin "4176	4,175.66
Continental mine, 1.1 miles south of, 2 feet east of trail, near point where trail crosses gulch below Dark Horse mine; point on rock marked "4773".	4,773.12

	Feet.
Continental mine, 0.8 mile south of, 5 feet east of trail, 6 feet north and 50 feet south of point where trail crosses second draw below Dark Horse mine; point on rock marked "4989"	4,989.18
Continental mine, 0.7 mile south of, 12 feet east of trail; point on rock marked "5167"	5,166.92
Continental mine, 400 feet south of shaft house, on outcropping rock above rock pile above slide; marked point on rock	5,774.26
Continental mine, 400 feet east of shaft house, near top of mound in center of upper saddle in ridge between Cedar Creek and Blue Joe Creek, stump 12 inches in diameter blazed and marked on all four sides; nail marked "5850"	5,850
Continental mine, 6 feet north of trail from Continental boarding house to Continental shaft house, at top of ridge between Cedar Creek and Blue Joe Creek, in solid rock outcrop; aluminum tablet stamped "5890"	5,890.001

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 488

RESULTS OF SPIRIT LEVELING IN NEVADA

1897 TO 1909, INCLUSIVE

R. B. MARSHALL, CHIEF GEOGRAPHER

WASHINGTON
GOVERNMENT PRINTING OFFICE
1911

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ILLUSTRATION.

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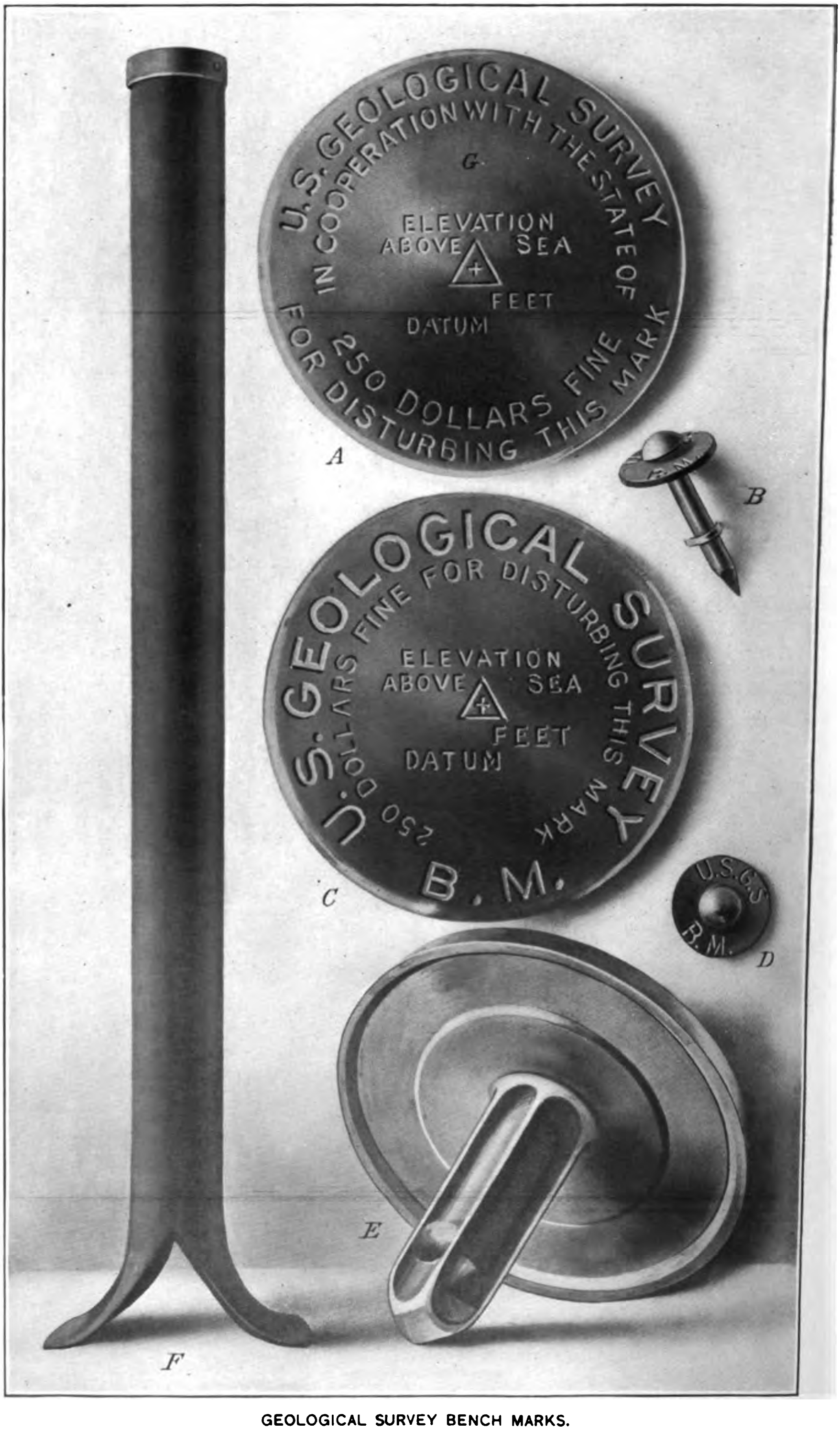
Plate I. Geological Survey bench marks 5



GEOLOGICAL SURVEY BENCH MARKS.

A, Tablet used in cooperating States. The State name is inserted at *G*.
B and *D*, Copper temporary bench mark, consisting of a nail and copper washer.
A, *C*, and *E*, Tablets for stone or concrete structures.
F, Iron post used where there is no rock.

RESULTS OF SPIRIT LEVELING IN NEVADA, 1897 TO 1909, INCLUSIVE.

R. B. **Marshall**, Chief Geographer.

INTRODUCTION.

Scope of the work.—All results of spirit leveling in Nevada previously published by the United States Geological Survey and all the results of later work are included in this report, rearranged by quadrangles. The elevations are based on preliminary heights of bench marks along the precise level line of the Coast and Geodetic Survey from San Diego via Barstow and Goffs, Cal., to Ogden, Utah, and on the precise line of the United States Geological Survey from Mohave, Cal., to Lida, Nev.

Personnel.—The field work previous to 1903 was done under the general direction of R. U. Goode, geographer; that for 1903 to 1906, inclusive, under E. M. Douglas, geographer; that for 1907 under R. B. Marshall, geographer; and the later work under T. G. Gerdine, geographer, under the general direction of R. B. Marshall, chief geographer. The names of the various levelmen are given in the introduction to each list. The office work of computation, adjustment, and preparation of lists was done mainly by S. S. Gannett, geographer, and D. H. Baldwin, topographer, and since 1907 under the general direction of E. M. Douglas, geographer.

Classification.—The elevations are classified as precise or primary according to the methods employed in their determination. For precise level lines instruments and rods of the highest grade are used, each line is run both forward and backward, and every precaution is taken to guard against error. The allowable divergence between the forward and the backward lines in feet is represented by the formula $0.017 \sqrt{D}$, in which D is the distance in miles between bench marks. For primary lines standard Y levels are used; lines are run in circuits or are closed on precise lines, with an allowable closing error in feet represented by $0.05 \sqrt{D}$, in which D is the length of the circuit in miles, sufficient care being given to the work to maintain this is not available, consists of a hollow wrought-iron post 3.5 inches in outer diameter and 4 feet in length. The bottom is spread out to a width of 10 inches, in order to give a firm bearing on the earth. A bronze or aluminum-bronze cap is riveted over the top of the post, which is set about 3 feet in the ground. A third style of bench mark with abbreviated lettering (*B* and *D*, Pl. I), is used for unimportant points. This consists of a special copper nail 1.5 inches in length driven through a copper washer seven-eighths inch in diameter. The tablets, as well as the caps on the iron posts, are appropriately lettered, and State cooperation is indicated by the addition of the State name (*G*, Pl. I).

The numbers stamped on the bench marks described in the following pages represent the elevations to the nearest foot as determined by the levelman. These numbers are stamped with $\frac{3}{16}$-inch steel dies on the tablets or post caps, to the left of the word "FEET." The office adjustment of the notes and the reduction to mean sea-level datum may so change some of the figures that the original markings are 1 or 2 feet in error. It is assumed that engineers and others who have occasion to use the bench-mark elevations will apply to the Director of the United States Geological Survey, at Washington, D. C., for the adjusted values, and will use the markings as identification numbers only.

Datum.—All United States Geological Survey elevations are referred to mean sea level, which is the level that the sea would assume if the influence of winds and tides were eliminated. This level is not the elevation determined from the mean of the highest and the lowest tides, nor is it the half sum of the mean of all the high tides and the mean of all the low tides, which is called the half-tide level. ***Mean sea level is the average height of the water, all stages of the tide being considered.*** It is determined from observations made by means of tidal gages placed at stations where local conditions, such as long, narrow bays, rivers, and like features, will not affect the height of the water. To obtain even approximately correct results these observations must extend over at least one lunar month, and if accuracy is desired they must extend over several years. At ocean stations the half-tide level and the mean sea level usually differ but little. It is assumed that there is no difference between the mean sea level as determined from observations in the Atlantic Ocean, the Gulf of Mexico, or the Pacific Ocean.

The connection with tidal stations for bench marks in certain areas that lie at some distance from the seacoast is still uncertain, and this fact is indicated by the addition of a letter or word to the right of the word "DATUM" on tablets or posts. For such areas corrections for published results will be made from time to time as the precise-level lines of the United States Geological Survey or other Government organizations are extended.

Topographic maps.—Maps of the following quadrangles, wholly or partly in Utah, have been published by the United States Geological Survey up to June 9, 1911. They may be obtained, for 5 cents each or $3 a hundred, on application to the Director of the Survey, at Washington, D. C.

Abajo (Utah-Colorado).
Ashley (Utah-Colorado).[1]
Beaver.
Bingham mining.
Coalville (Utah-Wyoming).[2]
Cottonwood special.
East Tavaputs (Utah-Colorado).
Escalante.
Fish Lake.
Fish Springs.
Frisco special.
Gilbert Peak (Utah-Wyoming).
Hayden Peak (Utah-Wyoming).[3]
Henry Mountains.
Iron Springs special.
Jensen (Utah-Colorado).
Kanab.
La Sal (Utah-Colorado).
Manti.
Marsh Peak (Utah-Wyoming).[1]
Park City special.
Pioche (Nevada-Utah).
Price River.
St. George.
Salt Lake.[2]
San Rafael.
Sevier Desert.
Strawberry Valley.[2]
Tintic mining.
Tintic special.
Tooele Valley.
Uinta.[3]

PRIMARY LEVELING.

Randolph and Saleratus Pass quadrangles.

RICH COUNTY.

The elevations in the following list are part of the leveling in 1909 in Idaho, Utah, and Wyoming, and are based on a bench mark of the Coast and Geodetic Survey, near Onyx, Bannock County, Idaho, described as follows: "Onyx, 1 mile north of, near signboard '1 mile to Onyx,' west of third telegraph pole south of milepost 197, west of track, 24 feet west of right of way fence, red sandstone post 6 feet long by 6 inches square, set in ground; bottom of square hole cut in top, marked "U. S. □ C. S." The elevation of this bench mark is accepted as 4,619.392 feet above mean sea level. From Onyx the line was run over the Oregon Short Line R. R. to a point 3.5 miles south of Montpelier, thence south by road via Laketown and Randolph, Utah, to Evanston, Wyo., closing on the Coast and Geodetic Survey bench mark at that point.

The leveling was done in 1909 by L. F. Biggs, with the exception of two bench marks in the Saleratus Pass quadrangle set by E. W. Hills in 1897. The closure errors of this line and circuits are excessive.

Additional elevations will be found in the Wyoming lists for the Randolph and Saleratus Pass quadrangles.

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[1] Marsh Peak sheet shows part of Ashley quadrangle on larger scale.
[2] Coalville and Strawberry Valley sheets show parts of Salt Lake quadrangle on larger scale.
[3] Gilbert Peak and Hayden Peak sheets show parts of Uinta quadrangle on larger scale.

RANDOLPH QUADRANGLE.[1]

Point near South Eden south along road via Laketown and Randolph to Woodruff.

	Feet.
South Eden, 1.6 miles north of, east side of road, on bowlder; painted "5937 B. M. 79;" chisel point	5,938.67
South Eden, 700 feet north of house, northeast corner of corral, west side of road; iron post stamped "5983 B 1909 C 1"	5,984.539
South Eden, 2.1 miles south of, east side of road, north end of steep grade, 100 feet south of old road down to lake, on bowlder painted "5940 B. M. 82;" chisel point	5,941.54
Laketown, 4 miles north of, north end of grove of poplar trees, opposite mouth of canyon, east edge of road, 25 feet east of lake; iron post stamped "5929 B 1909 D 1"	5,930.350
Laketown, 1.7 miles north of, fifth tree from north end of row of poplar trees, opposite log dam, in base of 30-inch poplar tree; spike; with aluminum tag stamped "5946 B. M. 85"	5,947.91
Laketown, northeast corner of Irwin's brick store, 4 feet above ground; aluminum tablet stamped "5988 B 1909 E 1"	5,989.979
Laketown, 2.7 miles south of, 1,000 feet east of creek where road makes sharp turn to east, south side of road, on bowlder painted "6336 B. M. 88;" chisel point	6,341.18
Laketown, 6.4 miles south of, east side of road, 150 feet north of forks of road on summit of ridge between Laketown and Randolph; iron post stamped "7129 B 1909 F 1"	7,130.727
Laketown, 8.6 miles south of, 6.3 miles north of Randolph, west side of road, opposite three small bold hills, on bowlder painted "6586 B. M. 92;" chisel point	6,587.74
Randolph, 5.7 miles north of, 600 feet south of Middle Fork of Otter Creek, 50 feet west of spring, west side of road; iron post stamped "6504 B 1909 G 1"	6,505.809
Randolph, 4 miles north of, south bank of South Fork of Otter Creek, 10 feet west of road, on bowlder painted "6487 B. M. 93;" chisel point	6,489.03
Randolph, 2.2 miles north of, northeast corner of field, at intersection of Logan-Randolph roads; iron post stamped "6407 B 1909 H 1"	6,409.449
Randolph, northeast corner of brick schoolhouse, 3 feet above ground; aluminum tablet stamped "6286 B 1909 I"	6,288.042
Randolph, 3.2 miles south of, east side of road, southwest corner of field belonging to Mrs. Mark Kennedy, north bank of irrigation ditch; iron post stamped "6265 B 1909 2"	6,267.190
Woodruff, 4.3 miles north of, 6.3 miles south of Randolph, on small rise, 1,500 feet northwest of log cabin, opposite braced telephone pole; iron post stamped "6302 B 1909 3"	6,305.139
Woodruff, northeast corner of brick schoolhouse, 4 feet above ground; aluminum tablet stamped "6342 B 1909 4"	6,343.884

Randolph northeast to fork of road 11.5 miles southwest of Cokeville, Wyo.

Randolph, 3.1 miles north of, 500 feet south of D. J. Jackson's ranch house, 150 feet north of lane, east edge of road; iron post stamped "6255 B 1909 11"	6,257.296
Randolph, 6.1 miles north of, 300 feet north of gate to Ed. Porters's ranch house, east edge of road, at fence line; iron post stamped "6287 B 1909 12"	6,289.001
Randolph, 8.1 miles north of, at junction of Sage-Cokeville road, 250 feet west of Sage Creek schoolhouse, west edge of road; iron post stamped "6256 B 1909 13"	6,257.763

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[1] For additional elevations in this quadrangle see the Wyoming list.

	Feet.
Sage Creek schoolhouse, 3.2 miles north of, east edge of road at northeast corner of field fence; iron post stamped "6237 B 1909 14"	6,238.400
Sage Creek schoolhouse, 4.3 miles north of, 1 mile south of Sixmile Creek, 15 feet east of road, on bowlder painted "6234 B. M. 125;" chisel point.	6,235.41
Sixmile Creek, 0.5 mile north of, east edge of road, on fence line, where road turns around point of hill; iron post stamped "6214 B 1909 15"	6,216.108
Sixmile Creek, 3.5 miles north of, 0.3 mile north of second-class road through Beckwith ranch, at junction of Cokeville and South Eden roads, 20 feet east of road; iron post stamped "6221 B 1909 16"	6,222.997
Sixmile Creek, 6.6 miles north of, 3.4 miles north of second-class road through Beckwith ranch, 3 miles north of junction of South Eden and Cokeville roads, 20 feet east of road, 1,700 feet south of junction of road leading west; iron post stamped "6220 B 1909 17"	6,221.931

SALERATUS PASS QUADRANGLE.[1]

Point near Woodruff southeast along road to Evanston, Wyo.

Woodruff, 3.8 miles southeast of, east end of lane, east end of marsh, at junction of road south, northeast corner of field; iron post stamped "6305 B 1909 5"	6,307.108
Woodruff, 6.9 miles southeast of, east side of road, on summit of rise, 2 miles north of small lake; iron post stamped "6353 B 1909 6"	6,355.537
Woodruff, 8.9 miles southeast of, 150 feet east of small lake, opposite rocky point, on bowlder painted "6440 B. M. 110;" chisel point.	6,442.35
Woodruff, 9.6 miles southeast of, 150 feet south of junction of road east, 1 mile south of lake, 50 feet west of road; iron post stamped "6464 B 1909 7"	6,466.136
Woodruff, 12.5 miles southeast of, 10 miles northeast of Evanston, east side of road, 1,500 feet south of log house, 150 feet west of irrigation ditch; iron post stamped "6574 B 1909 8"	6,577.042

Point 13.5 miles south of Evanston, Wyo., northwest 3.25 miles.

Evanston, 13.5 miles south of, 5 feet from wagon road, 200 yards west of sheep bridge and ford across Yellow Creek, 100 feet south of road fork; iron post stamped "7009 EVAN"	7,009.906
Evanston, 10.25 miles southwest of, 20 feet northwest of northwest corner of Wright's ranch house, west of Yellow Creek, 0.5 mile west of south group of Needle Rocks; iron post stamped "6892 EVAN"	6,892.731

Desert Lake, Moab, Mount Bartles, Mount Waas, Nephi, Price, Provo, Scofield, Tidwell, Westwater, and Woodside quadrangles.

CARBON, EMERY, SALT LAKE, UTAH, AND WASATCH COUNTIES.

The elevations in the following list were determined by a double line of primary leveling and constitute the Utah portion of the results of a line extended from Salt Lake, Utah, along the Denver & Rio Grande R. R. to Grand Junction, Colo. Corrections have been applied as in precise leveling, including orthometric corrections and adjustment of closure error of about 1 foot. The elevations adopted at Salt Lake and Grand Junction are in accordance with preliminary values by the Coast and Geodetic Survey for 1911. The results of a single unchecked primary line through the Harper, Desert Lake, and

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[1] For additional elevations in this quadrangle see the Emory quadrangle list, Wyoming.

Price quadrangles are also included in this list. The same corrections which were applied to the double line have also been applied to this line.

The leveling was done in 1910 by L. F. Biggs.

PROVO QUADRANGLE.

Riverton south along Denver & Rio Grande R. R. to Thistle.

	Feet.
Riverton, 2.5 miles south of, in base of milepost 56; spike with aluminum tag stamped "4434"	4,434.632
Oliver, in front of station; top of east rail	4,450.2
Riverton, 3.5 miles south of, in base of milepost 57; spike with aluminum tag stamped "4449"	4,449.662
Riverton, 4.5 miles south of, in base of milepost 58; spike with aluminum tag stamped "4443"	4,443.291
Riverton, 5.5 miles south of, in base of milepost 59; spike with aluminum tag stamped "4464"	4,464.146
Gravon, in front of station; top of east rail	4,473.3
Riverton, 6.5 miles south of, southeast corner of concrete bridge over Jordan River, 6 feet east of railroad track, opposite intake of canal; aluminum tablet stamped "4489-6"	4,488.968
Riverton, 7.5 miles south of, in base of milepost 61; spike with aluminum tag stamped "4521"	4,521.134
Lehi, 3 miles north of, in base of milepost 62; spike with aluminum tag stamped "4543"	4,543.723
Lehi, 2 miles north of, in base of milepost 63; spike with aluminum tag stamped "4542"	4,542.167
Lehi, 1 mile north of, in base of milepost 64; spike with aluminum tag stamped "4543"	4,543.804
Lehi, opposite ticket office; in floor of platform, spike	4,552.625
Lehi, east face of schoolhouse, south side of main entrance, 4 feet above ground, in cement; aluminum tablet stamped "4560-7"	4,561.083
Lehi, 1 mile south of, in base of signpost "Station 1 mile;" spike with aluminum tag stamped "4526"	4,526.881
Lehi, 2.5 miles south of, in base of milepost 67; spike with aluminum tag stamped "4523"	4,524.076
Lehi, 3.5 miles south of, in base of milepost 68; spike with aluminum tag stamped "4558"	4,558.867
American Fork, 200 feet south of station, 50 feet north of road crossing, 10 feet east of track, south side of concrete culvert of irrigation ditch; aluminum tablet stamped "4565-8"	4,565.295
American Fork, in front of station; top of east rail	4,565.5
American Fork, 0.5 mile south of, in base of milepost 69; spike with aluminum tag stamped "4550"	4,550.958
American Fork, 1.5 miles south of, in base of milepost 70; spike with aluminum tag stamped "4514"	4,514.907
American Fork, 2.5 miles south of, in base of milepost 71; spike with aluminum tag stamped "4495"	4,495.920
Geneva, west edge of railroad grade, southwest corner of concrete abutment 706A, 50 feet east of mouth of small creek 150 feet south of section house; aluminum tablet stamped "4496-9"	4,496.521
Utah Lake, surface of water, July 20, 1910, 11 a. m.	4,488.4
Geneva, 1.2 miles south of, in base of milepost 73; spike with aluminum tag stamped "4525"	4,525.732

	Feet.
Geneva, 2.2 miles south of, in base of milepost 74; spike with aluminum tag stamped "4536"	4,536.664
Geneva, 3.2 miles south of, in base of milepost 75; spike with aluminum tag stamped "4544"	4,544.196
Geneva, 4.2 miles south of, in base of milepost 76; spike with aluminum tag stamped "4544"	4,544.217
Geneva, 5.2 miles south of, in base of milepost 77; spike with aluminum tag stamped "4546"	4,547.097
Lakota, 1,100 feet south of station signpost, 50 feet east of railroad right of way, southwest corner of concrete bridge over irrigation canal; aluminum tablet stamped "4551-11"	4,551.982
Provo, 3.4 miles north of, in base of milepost 78; spike with aluminum tag stamped "4548"	4,548.721
Provo, 2.4 miles north of, in base of milepost 79; spike with aluminum tag stamped "4541"	4,541.254
Provo, 1.4 miles north of, in base of milepost 80; spike with aluminum tag stamped "4528"	4,528.909
Provo, 0.4 mile north of, in base of milepost 81; spike with aluminum tag stamped "4519"	4,519.710
Provo, 200 feet north of Denver & Rio Grande R. R. station, southwest corner of Z. C. M. I. building, 4 feet above ground, in brick wall; aluminum tablet stamped "4520-12"	4,520.841
Provo, west face of post office building, 3 feet south of main entrance, on top of coping above basement window; aluminum tablet stamped "4552-13"	4,552.430
Provo, 0.7 mile south of, in base of milepost 82; spike with aluminum tag stamped "4517"	4,518.012
Provo, 1.7 miles south of, in base of milepost 83; spike with aluminum tag stamped "4506"	4,507.235
Provo, 2.7 miles south of, in base of milepost 84; spike with aluminum tag stamped "4498"	4,498.779
Springville, 1.7 miles north of, northwest corner of concrete abutment of bridge 693A; aluminum tablet stamped "4503-14"	4,504.156
Springville, 1.4 miles north of, in base of milepost 86; spike with aluminum tag stamped "4547"	4,548.269
Springville, west face of Denver & Rio Grande R. R. station, 5 feet from entrance to waiting room, 4 feet above ground; aluminum tablet stamped "4561-15"	4,561.793
Springville, 0.6 mile south of, in base of milepost 87; spike with aluminum tag stamped "4576"	4,576.560
Springville, 1.6 miles south of, in base of milepost 88; spike with aluminum tag stamped "4628"	4,629.155
Springville, 2.6 miles south of, in base of milepost 89; spike with aluminum tag stamped "4679"	4,679.605
Springville, 3.6 miles south of, in base of milepost 90; spike with aluminum tag stamped "4712"	4,712.817
Mapleton, opposite station; top of east rail	4,729.2
Mapleton, 2,000 feet south of station, 650 feet southeast of milepost 91, 5 feet north of large field gate, at road crossing, east edge of railroad right of way, in sandstone monument 5 by 6 inches buried 3 feet in ground; aluminum tablet stamped "4739-16"	4,739.831
Milepost 92, in base of, 150 feet north of signpost "Station 1 mile," spike with aluminum tag stamped "4775"	4,775.338
Mapleton, 2 miles south of, in base of milepost 93, spike with aluminum tag stamped "4815"	4,815.496

	Feet.
Mapleton, 3 miles south of, in base of milepost 94; spike with aluminum tag stamped "4818"	4,818.563
Mapleton, 4 miles south of, east end of Reclamation Service dam of Strawberry Valley project; aluminum tablet stamped "4858–17"	4,858.524
Castello Springs, 0.6 mile north of, in base of milepost 97; spike with aluminum tag stamped "4896"	4,896.740
Castello Springs, west face of hotel, east side of main entrance, 4 feet above ground; aluminum tablet stamped "4918–18"	4,914.905
Castello Springs, 0.5 mile south of, northwest corner of steel railroad bridge 679, on stone abutment painted "4928;" chisel point	4,929.267
Castello Springs, 1.5 miles south of, in base of milepost 99; spike with aluminum tag stamped "4947"	4,947.511
Thistle, 1.4 miles north of, in base of milepost 100; spike with aluminum tag stamped "4978"	4,978.580

NEPHI QUADRANGLE.

Bench marks established near Thistle.

Thistle, 0.4 mile north of, in base of first telephone pole north of milepost 101; spike with aluminum tag stamped "5026"	5,027.163
Thistle, 1,100 feet south of station, 10 feet east of main-line track, east end of north abutment of bridge 676; aluminum tablet stamped "5041–19"	5,042.121
Thistle, 400 feet north of schoolhouse, 100 feet south of railroad right of way, near public road in rock ledge; aluminum tablet stamped "5050"	5,051.127

SCOFIELD QUADRANGLE.

Thistle southeast along Denver & Rio Grande R. R. to Colton.

Thistle, 0.4 mile southeast of, in base of milepost 102; spike with aluminum tag stamped "5061"	5,062.679
Thistle, 1.4 miles southeast of, in base of milepost 103; spike with aluminum tag stamped "5117"	5,118.168
Thistle, 2 miles southeast of, 1,800 feet north of milepost 104, southeast corner of concrete abutment of railroad bridge 674; aluminum tablet stamped "5151–20"	5,151.594
Thistle, 3.4 miles south of, in base of milepost 105; spike with aluminum tag stamped "5235"	5,236.055
Thistle, 4.4 miles southeast of, in base of milepost 106; spike with aluminum tag stamped "5304"	5,304.678
Thistle, 5.1 miles southeast of, 1,400 feet north of milepost 107, at road crossing; top of east rail	5,372.7
Thistle, 5.4 miles southeast of, in base of milepost 107; spike with aluminum tag stamped "5403"	5,404.036
Narrows, 250 feet north of station signpost, 10 feet east of east track, in large bowlder; aluminum tablet stamped "5498,–21"	5,499.075
Narrows, 1 mile southeast of, in base of milepost 109; spike with aluminum tag stamped "5596"	5,597.382
Narrows, 2 miles southeast of, in base of milepost 110; spike with aluminum tag stamped "5661"	5,662.133
Narrows, 3 miles southeast of, in base of milepost 111; spike with aluminum tag stamped "5698"	5,698.605
Narrows, 4 miles southeast of, in base of milepost 112; spike with aluminum tag stamped "5749"	5,750.578
Mill Fork, 150 feet north of station, west side of water tower, center one of three supports of tank, in stone cap; aluminum tablet stamped "5803,–23"	5,804.581
Mill Fork, 1.5 miles southeast of, in base of milepost 114; spike with aluminum tag stamped "5898"	5,899.635

	Feet.
Mill Fork, 2.5 miles southeast of, in base of milepost 115; spike with aluminum tag stamped "5955"	5,955.768
Mill Fork, 3.5 miles southeast of, 0.2 mile north of milepost 116, east edge of railroad right of way, west edge of wagon road, in large bowlder; aluminum tablet stamped "6014,-24"	6,015.496
Mill Fork, 4.5 miles southeast of, in base of milepost 117; spike with aluminum tag stamped "6073"	6,073.838
Milepost 118, in base of; spike with aluminum tag stamped "6132"	6,133.308
Tucker, 0.7 mile northwest of, in base of milepost 119; spike with aluminum tag stamped "6183"	6,183.967
Tucker, 1,000 feet south of station, 150 feet east of roundhouse, southeast corner of concrete retaining wall of railroad bridge A658; aluminum tablet stamped "6228,-25"	6,229.206
Tucker, 1 mile southeast of, 300 feet northwest of milepost 121, in base of signpost "Station 1 mile"; spike with aluminum tag stamped "6438"	6,433.938
Tucker, 2 miles southeast of, in base of milepost 122; spike with aluminum tag stamped "6649"	6,645.213
Media, 150 feet south of station, east edge of right of way, 10 feet above surface of track, in sandstone ledge; aluminum tablet stamped "6933,-26"	6,928.612
Media, 0.7 mile southeast of, in base of milepost 124; spike with aluminum tag stamped "7044"	7,040.061
Soldier Summit, 1.6 miles north of, in base of milepost 125; spike with aluminum tag stamped "7249"	7,245.011
Soldier Summit, 100 feet north of station, 50 feet east of south end of snow sheds, east edge of right of way, in large bowlder in fence corner; aluminum tablet stamped "7467-27"	7,463.210
Soldier Summit, 0.5 mile southeast of, in base of milepost 127; spike with aluminum tag stamped "7446"	7,442.378
Soldier Summit, 1.5 miles southeast of, in base of milepost 128, spike with aluminum tag stamped "7397"	7,393.686
Soldier Summit, 2.5 miles southeast of, in base of milepost 129; spike with aluminum tag stamped "7347"	7,342.840
Colton, 3.3 miles west of, 500 feet south of milepost 130, in base of telephone pole; spike with aluminum tag stamped "7295"	7,291.356
Colton, 2.5 miles northwest of, 500 feet west of milepost 131, south edge of railroad concrete culvert over drain; aluminum tablet stamped "7248,-28"	7,244.193
Colton, 1.5 miles northwest of, in base of milepost 132; spike with aluminum tag stamped "7215"	7,211.643
Colton, 0.5 mile northwest of, in base of milepost 133; spike with aluminum tag stamped "7186"	7,182.238
Colton, south face of public schoolhouse, 4 feet above ground, 3 feet west of main entrance; aluminum tablet stamped "7192,-29"	7,187.875

PRICE QUADRANGLE.

Colton southeast along Denver & Rio Grande R. R. to point 1.7 miles south of Farnham.

Colton, 1.7 miles southeast of, in base of milepost 135; spike with aluminum tag stamped "7136"	7,132.538
Colton, 2.7 miles southeast of, 10 feet west of milepost 137, east edge of track, concrete culvert over drain; aluminum tablet stamped "7100,-30"	7,096.467
Colton, 3.7 miles southeast of, in base of fourth telephone pole east of milepost 138; spike with aluminum tag stamped "7054"	7,050.482
Kyune, in base of milepost 139; spike with aluminum tag stamped "7029"	7,019.068
Kyune, 200 feet south of telegraph office, in north abutment of bridge 638B; aluminum tablet stamped "7012,-31"	7,014.024

	Feet.
Kyune, 0.8 mile south of, in base of milepost 140; spike with aluminum tag stamped "6947"	6,948.964
Kyune, 1.8 miles south of, 50 feet south of milepost 141, in base of whistling post; spike with aluminum tag stamped "6848"	6,850.013
Castle Gate, 5 miles north of, in base of milepost 142; spike with aluminum tag stamped "6747"	6,748.771
Castle Gate, 4 miles north of, in base of milepost 143; spike with aluminum tag stamped "6639"	6,641.112
Castle Gate, 3 miles southeast of milepost 144, 50 feet east of track, in bowlder; aluminum tablet stamped "6519,-32"	6,521.745
Castle Gate, 2 miles north of, in base of milepost 145; spike with aluminum tag stamped "6398"	6,399.927
Castle Gate, 1 mile north of, in base of milepost 146; spike with aluminum tag stamped "6279"	6,280.737
Castle Gate, 0.3 mile north of depot, 200 feet south of bridge, 10 feet east of switch signal, in large bowlder; aluminum tablet stamped "6146,-33"	6,147.922
Castle Gate, 200 feet north of station, at base of water plug; top of bolt head	6,112.408
Castle Gate, 1.3 miles southeast of, in base of milepost 149; spike with aluminum tag stamped "6007"	6,009.701
Castle Gate, 2.3 miles southeast of, in base of milepost 150; spike with aluminum tag stamped "5934"	5,936.745
Castle Gate, 3.3 miles southeast of, in base of milepost 151; spike with aluminum tag stamped "5860"	5,862.396
Helper, east face of Railroad Y. M. C. A. Building, 15 feet south of main entrance, 2 feet above ground; aluminum tablet stamped "5827,-34"	5,829.334
Helper, 0.4 mile southeast of, in base of milepost 152; spike with aluminum tag stamped "5804"	5,806.375
Helper, 1.4 miles southeast of, in base of milepost 153; spike with aluminum tag stamped "5759"	5,760.360
Helper, 2.8 miles southeast of, 0.3 mile south of milepost 154, north end of railroad cut, at road crossing, in base of telephone pole; spike with aluminum tag stamped "5689"	5,691.814
Price, 3.3 miles north of, 0.9 mile south of milepost 155, 60 feet east of right of way, on edge of bluff, in sandstone bowlder; aluminum tablet stamped "5663,-35"	5,664.912
Price, 2.3 miles north of, 0.4 mile south of milepost 156, at road crossing, in base of telephone pole; spike with aluminum tag stamped "5620"	5,622.726
Price, 1.3 miles north of, in base of milepost 157; spike with aluminum tag stamped "5572"	5,574.837
Price, 0.6 mile north of, in base of milepost 158; spike with aluminum tag stamped "5541"	5,543.605
Price, 50 feet south of south end of Denver & Rio Grande R. R. freight shed, in base of telephone pole; spike with aluminum tag stamped "5543"	5,544.980
Price, west face of courthouse, top of first coping of steps at south entrance of building; aluminum tablet stamped "5564,-36"	5,566.019
Price, 1 mile south of, 0.2 mile north of milepost 160, at road crossing, in base of telephone pole; spike with aluminum tag stamped "5507"	5,509.485
Price, 2 miles south of, in base of milepost 161; spike with aluminum tag stamped "5477"	5,479.045
Price, 2.6 miles south of, 0.3 mile north of milepost 162, at road crossing, in base of telephone pole; spike with aluminum tag stamped "5454"	5,456.072
Price, 3.8 miles south of, east side of concrete abutment of railroad bridge 615; aluminum tablet stamped "5434,-37"	5,436.107

	Feet.
Price, 5.2 miles south of, in base of milepost 163; spike with aluminum tag stamped "5413"	5, 415. 745
Wellington, in base of station signpost; spike with aluminum tag stamped "5405"	5, 407. 226
Wellington, 0.5 mile south of, in base of milepost 165; spike with aluminum tag stamped "5389"	5, 391. 946
Wellington, 1.5 miles south of, southeast corner of steel railroad bridge on stone abutment; aluminum tablet stamped "5459"	5, 361. 285
Wellington, 2.5 miles south of, in base of milepost 167; spike with aluminum tag stamped "5341"	5, 343. 553
Wellington, 3.5 miles south of, in base of milepost 168; spike with aluminum tag stamped "5327"	5, 329. 627
Wellington, 4.5 miles south of, in base of milepost 169; spike with aluminum tag stamped "5316"	5, 318. 085
Farnham, opposite station, 10 feet east of telephone, east edge of railroad right of way, in sandstone bowlder buried flush with ground; aluminum tablet stamped "5315"	5, 317. 375
Farnham, 0.7 mile south of, in base of milepost 170; spike with aluminum tag stamped "5325"	5, 327. 735
Farnham, 1.7 miles south of, in base of milepost 171; spike with aluminum tag stamped "5353"	5, 355. 421

Point 4 miles north of Desert Lake north and east along Sunnyside branch of Denver & Rio Grande R. R. to point 6 miles west of Sunnyside (single unchecked spur line).

Mounds, 4 miles north of, on Sunnyside branch of Denver & Rio Grande R. R., 20 feet east of milepost 4, in sandstone bowlder buried flush with ground; aluminum tablet stamped "5429"	5, 431. 768
Milepost 5, in base of; spike with aluminum tag stamped "5482"	5, 484. 705
Milepost 6, in base of; spike with aluminum tag stamped "5549"	5, 551. 350
Milepost 7, in base of; spike with aluminum tag stamped "5628"	5, 630. 162
Mounds, 4 miles north by 4 miles east of, 200 feet east of milepost 8, south edge of right of way, in sandstone bowlder; aluminum tablet stamped "5695"	5, 698. 064
Sunnyside, 6.1 miles west of, in base of sixth telephone pole west of milepost 9; spike with aluminum tag stamped "5760"	5, 762. 369
Sunnyside, 6 miles west of, on summit of small butte, 6 feet south of triangulation station; chisel point on bowlder painted "5812"	5, 814. 522
White, in base of station signpost; spike with aluminum tag stamped "5813"	5, 815. 372

DESERT LAKE QUADRANGLE.

Point 1.7 miles south of Farnham southeast along Denver & Rio Grande R. R. to point near Cedar.

Farnham, 2.7 miles south of, in base of milepost 172; spike with aluminum tag stamped "5381"	5, 383. 307
Mounds, 1.9 miles north of, 300 feet north of milepost 173, in north abutment of railroad bridge 605; aluminum tablet stamped "5386,–41"	5, 388. 341
Mounds, 1 mile north of, in base of second telephone pole north of milepost 174; spike with aluminum tablet stamped "5418"	5, 420. 658
Mounds, 150 feet east of station, 50 feet east of right of way, 15 feet north of small building; iron post stamped "5439,–42"	5, 441. 854
Milepost 176, in base of; spike with aluminum tag stamped "5389"	5, 391. 349
Milepost 177, in base of; spike with aluminum tag stamped "5339"	5, 341. 887
Milepost 178, in base of; spike with aluminum tag stamped "5293"	5, 295. 887
Verde, in base of station sign; spike with aluminum tag stamped "5267"	5, 268. 996

	Feet.
Verde, 0.7 mile south of, east end of south abutment of bridge 598B; aluminum tablet stamped "5233,-43"	5,235.153
Milepost 180, in base of; spike with aluminum tag stamped "5204"	5,206.287
Milepost 181, in base of; spike with aluminum tag stamped "5148"	5,150.587
Milepost 182, in base of; spike with aluminum tag stamped "5104"	5,106.473
Milepost 183, in base of; spike with aluminum tag stamped "5114"	5,116.581

Mounds north along Sunnyside branch of Denver & Rio Grande R. R. 4 miles (single unchecked spur line).

Mounds, 1 mile north of, in base of milepost; spike with aluminum tag stamped "5411"	5,413.854
Mounds, 2 miles north of, in base of milepost 2; spike with aluminum tag stamped "5377"	5,379.713
Mounds, 3 miles north of, in base of milepost 3; spike with aluminum tag stamped "5395"	5,397.554

WOODSIDE QUADRANGLE.

Cedar southeast along Denver & Rio Grande R. R. to point 1 mile west of Green River.

Milepost 184, in base of; spike with aluminum tag stamped "5155"	5,157.772
Cedar, east edge of right of way, 300 feet north of station, 10 feet south of telephone pole; iron post stamped "5172,-44"	5,174.432
Milepost 185, in base of; spike with aluminum tag stamped "5185"	5,187.152
Milepost 186, in base of; spike with aluminum tag stamped "5134"	5,136.857
Milepost 187, in base of; spike with aluminum tag stamped "5090"	5,092.363
Cedar, 3.6 miles east of, 400 feet west of milepost 188, north edge of right of way at east end of cut, in bowlder; aluminum tablet stamped "5040,-45"	5,042.009
Milepost 189, in base of; spike with aluminum tag stamped "4984"	4,986.979
Milepost 190, in base of; spike with aluminum tag stamped "4918"	4,920.942
Milepost 191, in base of; spike with aluminum tag stamped "4864"	4,866.174
Grassy, east edge of right of way, 50 feet south of station sign, 8 feet south of telephone pole; iron post stamped "4851,-46"	4,853.527
Milepost 192, in base of; spike with aluminum tag stamped "4800"	4,802.982
Milepost 193, in base of; spike with aluminum tag stamped "4764"	4,766.771
Milepost 194, in base of; spike with aluminum tag stamped "4708"	4,703.267
Woodside, 3 miles north of, west edge of north abutment of bridge 583B; aluminum tablet stamped "4614,-47"	4,685.339
Milepost 195, in base of; spike with aluminum tag stamped "4655"	4,657.302
Milepost 196, in base of; spike with aluminum tag stamped "4643"	4,645.213
Milepost 197, in base of; spike with aluminum tag stamped "4625"	4,627.582
Woodside, 400 feet south of station, west end of north abutment of steel railroad bridge; aluminum tablet stamped "4626,-48"	4,627.106
Milepost 198, in base of; spike with aluminum tag stamped "4648"	4,649.513
Milepost 199, in base of; spike with aluminum tag stamped "4665"	4,666.721
Milepost 200, in base of; spike with aluminum tag stamped "4691"	4,692.915
Milepost 201, in base of; spike with aluminum tag stamped "4737"	4,738.606
Milepost 202, in base of; spike with aluminum tag stamped "4784"	4,785.500
Cliff, 30 feet east of station signpost, 6 feet south of telephone pole, east edge of railroad right of way; iron post stamped "4824,-49"	4,826.032
Milepost 204, in base of; spike with aluminum tag stamped "4787"	4,788.298
Milepost 205, in base of; spike with aluminum tag stamped "4732"	4,733.412
Milepost 206, in base of; spike with aluminum tag stamped "4679"	4,680.330
Cliff, 3.2 miles south of, 0.4 mile south of milepost 206, east edge of railroad right of way, south of public-road crossing; iron post stamped "4663,-50"	4,664.577

	Feet.
Milepost 207, in base of; spike with aluminum tag stamped "4629".......	4, 630. 884
Milepost 208, in base of; spike with aluminum tag stamped "4586".......	4, 587. 811
Milepost 209, in base of; spike with aluminum tag stamped "4539".......	4, 540. 332
Desert, 100 feet south of station, east edge of right of way, 10 feet south of telephone pole; iron post stamped "4510,-51"........................	4, 511. 681
Milepost 211, in base of; spike with aluminum tag stamped "4456".......	4, 457. 457
Milepost 212, in base of; spike with aluminum tag stamped "4423".......	4, 424. 401
Milepost 213, in base of; spike with aluminum tag stamped "4396".......	4, 397. 217
Milepost 214, in base of; spike with aluminum tag stamped "4388".......	4, 390. 131
Desert, 5 miles south of, 500 feet north of milepost 214, in east end of south abutment of bridge 563; aluminum tablet stamped "4353,-2"....	4, 355. 460
Milepost 216, in base of; spike with aluminum tag stamped "4303".......	4, 304. 983
Sphinx, 50 feet north of station signpost, 10 feet south of telephone pole, at east edge of right of way; iron post stamped "4280,-52"..............	4, 281. 285
Milepost 218, in base of; spike with aluminum tag stamped "4248".......	4, 249. 975
Milepost 219, in base of; spike with aluminum tag stamped "4217".......	4, 218. 410
Milepost 220, in base of; spike with aluminum tag stamped "4167".......	4, 168. 658
Green River, 2.2 miles west of, east end of south abutment of bridge 557; aluminum tablet stamped "4142,-54"................................	4, 144. 189
Milepost 221, in base of; spike with aluminum tag stamped "4135".......	4, 136. 973

TIDWELL QUADRANGLE.

Point 1 mile west of Green River southeast along Denver & Rio Grande R. R. to point 1 mile east of Solitude.

Milepost 222, in base of; spike with aluminum tag stamped "4099".......	4, 101. 197
Green River, west face of public-school building, 5 feet south of main entrance, 3 feet above ground; aluminum tablet stamped "4085,-55"...	4, 087. 336
Green River, north abutment of steel railroad bridge over river; aluminum tablet stamped "4062"...	4, 062. 732
Milepost 225, in base of; spike with aluminum tag stamped "4101".......	4, 102. 291
Milepost 226, in base of; spike with aluminum tag stamped "4148".......	4, 149. 914
Green River, 4 miles east of east end of concrete culvert, 300 feet north of milepost 227; aluminum tablet stamped "4187,-55A"...................	4, 188. 424
Milepost 228, in base of; spike with aluminum tag stamped "4243".......	4, 244. 790
Milepost 229, in base of; spike with aluminum tag stamped "4295".......	4, 296. 507
Milepost 230, in base of; spike with aluminum tag stamped "4333".......	4, 334. 970
Solitude, 10 feet east of station signpost, west edge of right of way; iron post stamped "4372,-56"..	4, 373. 898
Milepost 232, in base of; spike with aluminum tag stamped "4426".......	4, 427. 687

MOAB QUADRANGLE.

Point 1 mile east of Solitude east along Denver & Rio Grande R. R. to point 1 mile west of White House.

Milepost 233, in base of; spike with aluminum tag stamped "4457".......	4, 458. 827
Milepost 234, in base of; spike with aluminum tag stamped "4494".......	4, 496. 114
Milepost 235, in base of; spike with aluminum tag stamped "4541".......	4, 542. 934
Milepost 236, in base of; spike with aluminum tag stamped "4594".......	4, 595. 998
Floy, 0.2 mile west of, east end of concrete abutment of bridge 541; aluminum tablet stamped "4616,-59"......................................	4, 617. 899
Milepost 238, in base of; spike with aluminum tag stamped "4619".......	4, 620. 832
Milepost 239, in base of; spike with aluminum tag stamped "4664".......	4, 665. 614
Milepost 240, in base of; spike with aluminum tag stamped "4713".......	4, 714. 888

	Feet.
Crescent, 2 miles west of, 15 feet east of second telephone pole east of milepost 241, east edge of railroad right of way; iron post stamped "4777,-60"	4,778.461
Milepost 242, in base of; spike with aluminum tag stamped "4816"	4,817.809
Milepost 243, in base of; spike with aluminum tag stamped "4875"	4,877.475
Crescent, 800 feet east of water tank, opposite milepost 244, at north edge of railroad right of way; iron post stamped "4898,-61"	4,899.747
Milepost 245, in base of; spike with aluminum tag stamped "4907"	4,908.804
Milepost 246, in base of; spike with aluminum tag stamped "4946"	4,948.526
Milepost 247, in base of; spike with aluminum tag stamped "5000"	5,002.061
Milepost 248, in base of; spike with aluminum tag stamped "5045"	5,047.522
Milepost 249, in base of; spike with aluminum tag stamped "5094"	5,096.012
Thompson, southeast corner of concrete abutment of bridge, 500 feet north of station; aluminum tablet stamped "5132,-62"	5,134.540
Milepost 251, in base of; spike with aluminum tag stamped "5126"	5,128.122
Milepost 252, in base of; spike with aluminum tag stamped "5084"	5,086.112
Thompson, 3.2 miles east of, 150 feet south of milepost 253, in south end of concrete abutment of steel bridge; aluminum tablet stamped "5033-63"	5,034.674
Milepost 254, in base of; spike with aluminum tag stamped "4983"	4,985.226
Milepost 255, in base of; spike with aluminum tag stamped "4937"	4,939.065
Milepost 256, in base of; spike with aluminum tag stamped "4887"	4,888.979
Milepost 257, in base of; spike with aluminum tag stamped "4832"	4,834.564
Sagers, 500 feet east of station, opposite milepost 258, west edge of right of way; iron post stamped "4782-64"	4,783.961
Milepost 259, third telephone pole east of, in base of signpost; spike with aluminum tag stamped "4727"	4,727.665
Milepost 260, in base of; spike with aluminum tag stamped "4680"	4,681.658
Milepost 261, in base of; spike with aluminum tag stamped "4630"	4,631.841
White House, 4.3 miles west of, southeast corner of concrete culvert of bridge; aluminum tablet stamped "4621-65"	4,622.989
Milepost 262, in base of; spike with aluminum tag stamped "4605"	4,607.669
Milepost 263, in base of; spike with aluminum tag stamped "4571"	4,572.883
Milepost 264, in base of; spike with aluminum tag stamped "4553"	4,555.266

MOUNT WAAS QUADRANGLE.

Point 1 mile west of White House northeast along Denver & Rio Grande R. R. to Cisco.

Milepost 265, in base of; spike with aluminum tag stamped "4506"	4,508.209
White House, 6 feet east of station signpost, north edge of railroad right of way; iron post stamped "4485-66"	4,486.793
Milepost 267, 300 feet west of, in base of signpost; spike with aluminum tag stamped "4451"	4,452.849
Milepost 268, in base of; spike with aluminum tag stamped "4434"	4,436.649
Milepost 269, in base of; spike with aluminum tag stamped "4449"	4,450.893
Cisco, 3.7 miles west of, opposite milepost 270, east edge of railroad right of way; iron post stamped "4455-67"	4,457.200
Milepost 271, in base of; spike with aluminum tag stamped "4406"	4,408.111
Milepost 272, in base of; spike with aluminum tag stamped "4351"	4,352.895
Milepost 273, in base of; spike with aluminum tag stamped "4331"	4,331.893
Cisco, 25 feet east of station, in corner of railroad park; iron post stamped "4350-68"	4,352.953
Milepost 274, in base of; spike with aluminum tag stamped "4360"	4,361.888

WESTWATER QUADRANGLE.

Cisco northeast along Denver & Rio Grande R. R. to Utaline.

	Feet.
Milepost 275, in base of; spike with aluminum tag stamped "4326"	4,327.671
Milepost 276, in base of; spike with aluminum tag stamped "4314"	4,315.786
Milepost 277, in base of; spike with aluminum tag stamped "4316"	4,317.308
Milepost 278, in base of; spike with aluminum tag stamped "4315"	4,316.067
Marrs, 250 feet east of station signpost, 6 feet south of second telephone pole, south edge of railroad right of way; iron post stamped "4346-69"	4,347.667
Milepost 280, in base of; spike with aluminum tag stamped "4347"	4,348.383
Milepost 281, in base of; spike with aluminum tag stamped "4380"	4,381.317
Milepost 282, in base of; spike with aluminum tag stamped "4423"	4,424.681
Milepost 283, in base of; spike with aluminum tag stamped "4434"	4,435.585
Milepost 284, in base of; spike with aluminum tag stamped "4485"	4,486.545
Cottonwood, 1,000 feet east of station, south end of cut, 10 feet north of track, 50 feet west of milepost 285, in sandstone bowlder; aluminum tablet stamped "4548-70"	4,549.297
Milepost 286, in base of; spike with aluminum tag stamped "4498"	4,499.997
Milepost 287, in base of; spike with aluminum tag stamped "4444"	4,445.976
Milepost 288, in base of; spike with aluminum tag stamped "4383"	4,384.946
Milepost 289, in base of; spike with aluminum tag stamped "4329"	4,330.785
Westwater, 25 feet north of station, east end of station signpost; iron post stamped "4320-71"	4,320.487
Milepost 290, in base of; spike with aluminum tag stamped "4318"	4,319.602
Milepost 291, in base of; spike with aluminum tag stamped "4333"	4,331.761
Milepost 292, in base of; spike with aluminum tag stamped "4341"	4,339.895
Milepost 293, in base of; spike with aluminum tag stamped "4340"	4,338.685
Utaline, 20 feet north of station signpost, on Utah-Colorado State line, in sandstone ledge; aluminum tablet stamped "4353-72"	4,354.819

MOUNT BARTLES QUADRANGLE.

Point 5.5 miles west of Sunnyside east along Sunnyside branch of Denver & Rio Grande R. R. to Sunnyside (single unchecked spur line).

Sunnyside, 4 miles west of, north side of right of way, under center of signal at triangulation station, in sandstone bowlder buried flush with ground; aluminum tablet stamped "5902"	5,904.386
Milepost 12, in base of; spike with aluminum tag stamped "6042"	6,044.781
Milepost 13, in base of; spike with aluminum tag stamped "6166"	6,168.417
Milepost 14, in base of; spike with aluminum tag stamped "6294"	6,296.463
Sunnyside, 100 feet south of milepost 15, south edge of railroad right of way, in sandstone bowlder; aluminum tablet stamped "6432"	6,434.419

Fish Springs and Sevier Desert quadrangles.

JUAB AND MILLARD COUNTIES.

The elevations in this list are based on a bench mark at Oasis, an iron post at the southwest corner of Day's Hotel, the elevation of which by the field computation of the Coast and Geodetic Survey precise leveling of 1908 is accepted as 4,593.053 feet. Its final value has not yet been computed by the Coast and Geodetic Survey. When determined the correction should be applied to this entire list.

The leveling was done in 1908 by T. A. Green.

SEVIER DESERT QUADRANGLE.

Oasis to Drum (Joy post office).

	Feet.
Oasis, southwest corner of Day's Hotel; iron post stamped "4591-1908"	4,593.053
Oasis, in front of station; top of rail	4,595.6
Deseret, 75 feet east of crossroads, south of post office, at corner of corporation scales; top of bolt marked "4584"	4,585.87
Deseret, 5.08 miles northwest of, 100 feet north of road, in 6 by 12 by 24 inch rock; aluminum tablet stamped "4572"	4,573.710
Deseret, 10.92 miles northwest of, 50 feet north of road; iron post stamped "4559"	4,560.723
Deseret, 16.69 miles northwest of, 1.12 miles northwest of old smelter, 30 feet east of road, in oblong rock; aluminum tablet stamped "4681"	4,682.942
Joy, 11 miles southeast of, 10 feet west of road, in brown sandstone bowlder 30 inches wide and 18 inches deep; bronze tablet stamped "5028"	5,030.076

Antelope Spring east to Deseret (portion of line).

Soap Hollow, 7.18 miles east of, at forks of road, on east side of Swassie Wash, 50 feet east of forks; iron post stamped "4680"	4,682.057
Crafts, 2.75 miles northwest of, 40 feet north of road; iron post stamped "4553"	4,554.942
Crafts, 1.75 miles northwest of, on west side of road at northwest corner of lake; point on rock marked "4542"	4,551.75
Crafts, 3.18 miles northwest of, 20 feet west of road, on top of small ridge; iron post stamped "4561"	4,563.527
Deseret, 3.4 miles west of, 30 feet east of road, 130 feet north of forks; iron post stamped "4573"	4,574.714

FISH SPRINGS QUADRANGLE.

Drum (Joy post office) via Fish Springs to Callao.

Joy, 5 miles southeast of, 20 feet east of road, at sharp bend to north, in rock; aluminum tablet stamped "5653"	5,655.360
Joy, 3 miles southeast of, 75 feet north of road, running east to Ibex mine; point on rock	5,942.65
Joy, 0.87 mile southeast of post office, 5 feet east of road; point on mining claim monument	5,973.42
Joy (Drum), 0.6 mile west of post office, 100 feet south of road, 325 feet west of four-corners, on top of small hill, in porphyry outcrop; aluminum tablet stamped "5954"	5,955.830
Joy, 5.21 miles northwest of, 30 feet south of road, at plane table station, in rock; aluminum tablet stamped "5333"	5,335.109
Joy, 11.84 miles northwest of, 30 feet east of road, in rock; aluminum tablet stamped "4743"	4,745.159
Cane Spring, 8.3 miles southeast of, north side of road, 160 feet west of freighter's camp ground; point on rock	4,540.74
Cane Spring, 5 miles southeast of, 870 feet west of road running north, 20 feet north of road, in rock; aluminum tablet stamped "4390"	4,391.535
Cane Spring, 0.67 mile north of, on east side of road, 50 feet north of freighter's feed box and cedar post, in rock; aluminum tablet stamped "4337"	4,338.719
Thomas ranch, in east side of old stone house occupied by J. J. Thomas, on north side of south door; aluminum tablet stamped "4319"	4,320.665
Thomas ranch, 2.80 miles north of, 200 feet west of northwest corner of Fish Spring; point on quartz outcrop	4,308.18
Thomas ranch, 4.11 miles northwest of, 140 feet west of road running north to Hat Springs, 30 feet south of road, at point where road makes sharp bend to southwest; point on rock	4,308.26

	Feet.
Fish Springs, 1.8 miles southest of, 200 feet west of road, near western end of black mesa; iron post stamped "4340"	4,341.625
Fish Springs, about 1 mile west of, at forks of road, in southwest corner of casing around old well; nail	4,334.23
Fish Springs, about 2 miles west of, at old well on east side of road; top of iron standpipe	4,344.27
Fish Springs, 4.39 miles west of, at junction with main road running southwest to Trout Creek, 40 feet north of road junction; iron post stamped "4348"	4,349.560
Callao, 4.6 miles east of, 40 feet north of road; iron post stamped "4326"	4,327.895

Callao via Trout Creek to Gandy, Smithville, and Cowboy Pass.

Callao, 200 feet southeast of southeast corner of John Kearney's ranch house, on south side of road, 10 feet west of field gate; iron post stamped "4326"	4,328.292
Callao, 6.16 miles southwest of, 1,280 feet south of running stream crossing, 40 feet west of road; iron post stamped "4813"	4,814.740
Callao, 9.61 miles southwest of, 40 feet west of road, 900 feet west of old dry lake, in large granite bowlder; aluminum tablet stamped "4974"	4,975.949
Trout Creek, 2.8 miles north of, 28 feet west of road, 15 feet due west of bowlder, in rock; aluminum tablet stamped "4821"	4,822.266
Trout Creek, 1.6 miles north of, 40 feet north of road junction; iron post stamped "4679"	4,681.113
Trout Creek, 4.84 miles south of, 25 feet west of road, on top of sandy ridge, between two salt marshes; iron post stamped "4735"	4,737.555
Trout Creek, 7.81 miles south of, 10 feet east of road, 30 feet south of four-corners; point on lava rock	4,773.90
Gandy, 9 miles north of, 50 feet west of junction with road running southwest, 10 feet south of road; iron post stamped "4837"	4,839.311
Gandy, 3.2 miles north of, 40 feet west of road, 150 feet south of road running northwest; iron post stamped "5014"	5,016.340
Gandy, 2.42 miles southeast of, 35 feet west of road, 1,175 feet north of road running north, in rock; aluminum tablet stamped "4949"	4,950.292
Smithville, 1,260 feet west of post office, 100 feet south of road, 40 feet west of gate to George Bishop's ranch house, in rock; aluminum tablet stamped "4881"	4,883.590
Smithville, 6.15 miles south of, 20 feet west of road, 270 feet south of point where road crosses sand dunes, in marble rock; aluminum tablet stamped "4889"	4,890.938
Simonson's ranch, 300 feet northeast of, at northwest corner of field fence, in rock; aluminum tablet stamped "4956"	4,958.362
Simonson's ranch, 6.25 miles east of, 15 feet south of road; iron post stamped "4867"	4,869.207
Cowboy Pass, 4.6 miles west of, 40 feet south of road, in rock; aluminum tablet stamped "5162"	5,164.110
Cowboy Pass, 3.1 miles west of, 5 feet south of road, at point where road makes a sharp bend to east into mouth of canyon; point on rock	5,353.50

Gandy via Foote's ranch and Bishop Spring to Cowboy Pass.

Foote's ranch, 4.6 miles northwest of, 5 feet north of road, at southeast corner of fence around Conkling's ranch; iron post stamped "4826"	4,835.090
Foote's ranch, 0.8 mile northwest of, on north side of road, 300 feet west of dim road north; iron post stamped "4819"	4,827.010
Bishop Spring, 0.9 mile northwest of, 10 feet east of road, 300 feet northeast of Foote's Spring; point on rock marked "4817"	4,825.21

	Feet.
Bishop Spring, 6.12 miles southeast of, 10 feet south of road, 70 feet east of road west to Smithville, in rock; aluminum tablet stamped "4962"	4, 971. 442

Cowboy Pass to Tule Spring.[1]

Cowboy Pass, 50 feet north of road, 10 feet west of divide, in limestone outcrop; aluminum tablet stamped "5707"	5, 716. 181
Cowboy Pass, 6.1 miles east of, 15 feet south of road, in limestone rock, beside rock monument; aluminum tablet stamped "4841"	4, 850. 445
Tule Spring, 15 feet east of North Spring, 20 feet north of road; iron post stamped "4411"	4, 420. 444

Bishop Spring to Tule Spring.

Bishop Spring, 3.2 miles southeast of, at point where road makes sharp bend to northwest, on south end of small nose, in limestone outcrop; aluminum tablet stamped "5176"	5, 185. 315
Bishop Spring, 8.5 miles southeast of, forks of road at top of divide, 40 feet east of divide, 50 feet north of forks, in limestone rock; aluminum tablet stamped "5963"	5, 972. 288
Tule Spring, 9.97 miles northwest of, on north side of road, 25 feet east of dim road south, at mouth of canyon; point on rock marked "5376"	5, 385. 77
Tule Spring, 6.15 miles northwest of, 20 feet north of road; iron post stamped "4735"	4, 744. 313

Point 2.1 miles northwest of Joy via Swasey Spring road to crossroads, 4.5 miles east of Antelope Spring.

Joy, 8.26 miles southwest of, 40 feet east of road; iron post stamped "5146"	5, 147. 973
Joy, 14.5 miles southwest of, 20 feet west of road; iron post stamped "5026"	5, 027. 556
Joy, 21.29 miles southwest of, 50 feet east of road, in blue limestone rock; aluminum tablet stamped "5222" (witness mark, slate slab 2 feet east of tablet)	5, 223. 699

Tule Spring via Antelope Spring and Crafts to Deseret.

Tule Spring, 6.06 miles east of, 45 feet north of road, in rock on west side of rock monument; aluminum tablet stamped "4759"	4, 768. 779
Antelope Spring, 1.16 miles west of, at top of main divide of House range, 20 feet north of road, 15 feet west of divide, in limestone outcrop; aluminum tablet stamped "6740"	6, 742. 432
Antelope Spring, 5.05 miles east of, 40 feet south of road, on end of small nose between two washes, in oblong bowlder; aluminum tablet stamped "5547"	5, 549. 503
Soap Hollow, 1.5 miles east of, at top of ridge, 200 feet east of saddle, 50 feet north of road, in sandstone outcrop; aluminum tablet stamped "5001"	5, 002. 731

Tintic special quadrangle.

JUAB AND UTAH COUNTIES.

The approximate elevations in the following list are based on an iron post set in the ground at the northeast corner of the courthouse at Eureka and stamped "6394." The height of this post is derived from the elevation of the top of the rail in front of the station of the San Pedro, Los Angeles & Salt Lake R. R. at Eureka, given as 6,387 feet by the railway officials. From this the elevation of the central datum point has been accepted as 6,394.453 feet above mean sea level.

The leveling was done in 1897 by A. B. Searle.

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[1] The error of this line is excessive.

Eureka to Diamond Divide via Robinson, Silver City, and Diamond.

	Feet.
Eureka, junction of San Pedro, Los Angeles & Salt Lake R. R. and Denver & Rio Grande R. R.; top of rail	6,177.59
Robinson, southeast corner of lawn at Hotel Mammoth; iron post stamped "6382"	6,381.755
Diamond, northwest corner of lot, in southeast angle of cross streets in center of town; iron post stamped "6240"	6,240.417
Diamond Divide, beside large rock at base of small cedar tree, at east end of long flat near head of Water and Government canyons; iron post stamped "6790"	6,789.505

Silver City down Tintic Valley to point near McIntire's ranch.

T. 11 S., R. 3 W., northwest corner of sec. 14, junction of road from Silver City and road from Mammoth to McIntire's ranch, west side of old grade of Denver & Rio Grande R. R., about 500 feet north of trestle; iron post stamped "5686"	5,686.418
T. 12 S., R. 3 W., SE. ¼ NW. ¼ sec. 11, on north side of draw, in angle formed by road from McIntire's ranch and old road leading off to northeast; iron post stamped "5771"	5,771.368

Up Copperopolis Creek.

T. 12 S., R. 3 W., northeast corner of sec. 1, mound of earth just south of wagon road at junction of drainages; iron post stamped "6124"	6,124.419

Up Kimball Creek.

Big and Little Dog canyons, near junction of, on east side of wagon road, about 0.2 mile north of junction of streams; iron post stamped "5739"	5,739.079

Up Cottonwood Canyon.

Cottonwood Canyon, head of, about 600 feet east of wagon road, about 250 feet north of Juab County, Utah County line, under lone tree; iron post stamped "6228"	6,228.089

Diamond Divide to Eureka, via Government Canyon, Iron Spur, and Homansville.

Goshen Valley, northwest corner of T. 11 S., R. 1 W.; iron post stamped "4793"	4,793.136
Goshen Valley, at northwest corner of T. 10 S., R. 1 W.; iron post stamped "4978"	4,978.475

Frisco special quadrangle.

BEAVER COUNTY.

The elevations in the following list are based on the height of a bench-mark post 400 feet north of the station at Milford, accepted as 4,955.974 feet, as determined by the Coast and Geodetic Survey preliminary 1911 adjustment.

The leveling was done in 1904 by R. A. Farmer and in 1905 by Fred McLaughlin, and was originally based on railroad datum; hence the erroneous stamping of bench marks.

Milford west along San Pedro, Los Angeles & Salt Lake R. R. (Frisco branch) to Frisco (mean of two runs).

	Feet.
Milford, in front of station; top of rail	4,958.5
Milford, 300 feet south of station, 50 feet west of main track, 5 feet north of telephone pole; iron post stamped "5035"	4,957.628

	Feet.
Milford, 400 feet north of station, 50 feet west of main track, 10 feet south of telephone pole; iron post stamped "5034" (Coast and Geodetic Survey value)	4,955.974
Milford, 1 mile south of, 8 feet west of milepost 259, 20 feet north of track; iron post stamped "5059 F R R"	4,981.254
Milepost 262, 10 feet north of, 20 feet north of track; iron post stamped "5229 F R R"	5,151.400
Solus, 2.5 miles east of, 100 feet east of bridge 224, 20 feet north of track; iron post stamped "5495 F R R"	5,417.640
Solus, 20 feet south of signboard, 30 feet south of track; iron post stamped "5726"	5,647.920
Frisco, 4.5 miles east of, 15 feet east of milepost 270, 20 feet north of track; iron post stamped "5946"	5,868.369
Frisco, 2 miles east of, 150 feet east of trestle 236, 25 feet north of track; iron post stamped "6364"	6,286.429
Frisco, 100 feet east of station, 30 feet north of track, east side of Main Street; iron post stamped "6450 F R R"	6,372.238

Frisco west along highway to Newhouse (single line checked by secondary leveling).

Frisco, 100 feet south of station; iron post stamped "6443"	6,364.947
Squaw Springs, 1.3 miles west of, 100 feet south of wagon road, in black rock 1 by 3 by 2 feet out of ground; tablet stamped "5862"	5,783.904
Newhouse, 10 feet east of reservoir; iron post stamped "5320"	5,242.054

Iron Springs special quadrangle.

IRON COUNTY.

The elevations in the following list depend upon the height of a bench mark at Lund station accepted as 5,080.831 feet, as determined by the Coast and Geodetic Survey preliminary 1911 adjustment.

The leveling was done in 1905 by George F. Maglett.

Lund southeast along road to Hamilton Fort.

	Feet.
Lund, 200 feet north of station, 50 feet west of main track, 10 feet east of road; iron post stamped "RLUND 5092"	5,080.831
Lund, 3 miles southeast of, 20 feet south of road; iron post stamped "RLUND 5106"	5,095.848
Lund, 6 miles southeast of, 20 feet south of road; iron post stamped "RLUND 5131"	5,120.350
Lund, 9 miles southeast of, 20 feet south of road; iron post stamped "RLUND 5168"	5,158.321
Lund, 12 miles southeast of, 20 feet south of road; iron post stamped "RLUND 5203"	5,192.561
Lund, 15 miles southeast of, 15 feet south of road; iron post stamped "RLUND 5263"	5,253.239
Lund, 18 miles southeast of, 20 feet south of road; iron post stamped "RLUND 5317"	5,307.045
Lund, 20.75 miles southeast of, 100 feet south of road, 15 feet northeast of old rock house; iron post stamped "RLUND 5365"	5,354.456
Lund, 23 miles southeast of, 400 feet southwest of Root's house, 20 feet southwest of road; iron post stamped "RLUND 5414"	5,404.071
Iron Springs, 0.25 mile east of, 20 feet east of road forks; iron post stamped "RLUND 5470"	5,460.101
Iron Springs, 3.25 miles south of, 50 feet south of road forks; iron post stamped "RLUND 5495"	5,484.712

	Feet.
Iron Springs, 6.5 miles south of, 2.5 miles west of Hamilton Fort, 20 feet northeast of road; iron post stamped "RLUND 5497"	5,486.798
Iron Springs, 9.25 miles south of, 0.25 mile west of Hamilton Fort, 15 feet north of road forks; iron post stamped "RLUND 5631"	5,620.893

Hamilton Fort west to Duncan's ranch, thence north to point 9 miles southeast of Lund.

Shirts Lake, 200 feet west of, 1 mile northwest of house, 10 feet west of road; iron post stamped "RLUND 5454"	5,443.957
Hamilton Fort, 7 miles west of, 15 feet north of Cedar City and Pinto Creek road; iron post stamped "RLUND 5689"	5,679.011
Duncan's ranch, 600 feet northeast of house, 30 feet south of road forks; iron post stamped "5983 RLUND"	5,972.830
Duncan's ranch, 3 miles north of, 3,000 feet north of road forks, 20 feet east of road; iron post stamped "RLUND 5843"	5,832.742
Duncan's ranch, 11 miles north of, 3.5 miles due west of old rock house, 1,200 feet south of Iron Springs-Antelope road; iron post	5,414.334
Old rock house, 9 miles west of, 4 miles northeast Antelope Springs, 70 feet south of road forks; iron post stamped "RLUND 5367"	5,355.774
Antelope Spring, 5.75 miles northeast of, 3.75 miles north of road forks, 0.5 mile east of Pioche-Hot Springs road; iron post stamped "RLUND 5187"	5,176.702

Browns Park, Coalville, Fort Douglas, Gilbert Peak, Hayden Peak, Marsh Peak, Red Creek, Strawberry Valley, Theodore, and Vernal 30′ quadrangles (Ashley, Salt Lake, and Uinta 1° quadrangles).

SALT LAKE, SUMMIT, UINTA, UTAH, AND WASATCH COUNTIES.

The elevations in the following list are based upon the heights of bench marks of the United States Geological Survey at Evanston, Wyo., and Echo, Utah, redetermined by the transcontinental precise level line of the Coast and Geodetic Survey.

The leveling was done in the Coalville quadrangle in 1899 and 1900 by L. C. Woodbury and E. W. Glafcke, respectively; in the Gilbert Peak, Marsh Peak, and Vernal quadrangles in 1902 by Glafcke; in the Strawberry Valley and Red Creek quadrangles in 1900 by Glafcke; in the Theodore quadrangle in 1900–1901 by Glafcke; in the Hayden Peak quadrangle in 1897–98 by E. W. Hills and in 1901–2 by Glafcke; and in the Fort Douglas quadrangle in 1899 and 1901 by Woodbury and Glafcke, respectively. Additional leveling was done in the Browns Park and Marsh Peak quadrangles in 1905 by J. H. Kent and in the Fort Douglas quadrangle in 1910 by L. F. Biggs, the work in the latter quadrangle being a portion of the double line from Salt Lake City, Utah, to Grand Junction, Colo.

FORT DOUGLAS 30′ QUADRANGLE (SALT LAKE 1° QUADRANGLE).

Salt Lake City east along Denver & Rio Grande R. R. to Kimballs (double-rodded line).

	Feet.
Salt Lake City, in front of Oregon Short Line R. R. station; top of rail	4,255.0
Salt Lake City, meridian mark at the southwest corner of city and county building grounds, corner of State and Fifth streets south, cemented in stone post; bronze tablet stamped "4251 SLAK"	4,252.171

	Feet.
Salt Lake City, at southeast corner of brick building known as Cook's Hall, at corner of Ninth Street East and Twelfth Street South, on top of projecting brick; cut cross	4,331.02
Salt Lake City, corner Eleventh Street East and Twelfth Street South, 2 feet north of sidewalk and 100 feet northeast of street crossing; iron post stamped "4352 SLAK"	4,353.867
Salt Lake City, 7.8 miles southeast of, 2.0 miles east of Starbuck's "Model Dairy Ranch," in east end of north wall of city waterworks reservoir; top of bolt head stamped "4736"	4,737.83
Salt Lake City, 11.5 miles southeast of, 3.6 miles southeast of city waterworks, 0.25 mile below section house at road crossing, between railroad and creek; iron post stamped "5234 SLAK"	5,235.760
Barclay, below railroad and above water tank and section house; iron post stamped "6204 SLAK"	6,205.840
Summit, about 100 feet east of wagon road, on side of hill just below oak brush; iron post stamped "7041 SLAK"	7,041,950
Summit, 3.7 miles southeast of, beside railroad, back of buildings at Anderson's ranch, about 0.5 mile east of Gogorza; iron post stamped "6304 SLAK"	6,305.830
Kimball's, fence corner at road crossing; iron post stamped "6364 SLAK"	6,365.615

Kimball's southeast to Park City (double spur line).

Park City, 3.4 miles northwest of, west side of railroad track, north side of public road, at fence corner; iron post stamped "6636 SLAK"	6,636.828
Park City, 1.0 mile north of, sec. 9, T. 2 S., R. 4 E., at side of public road 50 feet west of southeast corner of cemetery fence; iron post stamped "6804 SLAK"	6,805.660
Park City, sec. 16, T. 2 S., R. 4 E., first ward school building, northeast corner of grounds; iron post stamped "6973 SLAK"	6,974.777

Deer Park south up Ontario Gulch to top of mountains above Quincy mine and back through Empire Canyon.

Ontario mill, mouth of old drain tunnel, northeast corner of masonry wall, top of foundation stone; chisel mark	7,274.51
T. 2 S., R. 4 E., NW. ¼ sec, 28, Daily mine No. 2, northwest corner of stone embankment around front yard of boarding house; aluminum tablet stamped "8176 SLAK"	8,177.029
T. 2 S., R. 4 E., east side of sec. 29, Quincy mine No. 1, 100 feet west of hoist works, on north slope of divide, at head of Empire Canyon, in large quartzite ledge; aluminum tablet stamped "8499 SLAK"	8,500.214
Daily West mine, southeast corner of scales, in heavy timber, 50 feet north of assay office; marked nail	8,331.50
Daily No. 1 mine, southwest corner of hoist works, in foundation stringer, spike	8,084.81
T. 2 S., R. 4 E., SW. ¼ sec. 21, 300 feet southwest of house at mouth of canyon, west side of narrow canyon, in cliff, 20 feet west of road; aluminum tablet stamped "7658 SLAK"	7,659.505

Quincy mine via Brighton, Alta, Bonanza Flat, and Silver Lake to point 4 miles northwest of Brighton Hotel (spur line).

Divide between Bonanza Flat and Big Cottonwood Creek, summit of, 75 feet south of road, in large granite bowlder; aluminum tablet stamped "9750 SLAK"	9,740.409
Silver Lake, Brighton Hotel, 15 feet north of north end of lake, in large bowlder; aluminum tablet stamped "8739 SLAK"	8,729.269

	Feet.
Alta Divide, summit of, between Twin Lakes and Little Cottonwood Creek, 20 feet north of trail, in granite ledge, beside rock; aluminum tablet stamped "10002 SLAK"	9,992.271
Alta, 100 feet north of road between Columbus Mine and Alta, in ledge of limestone on small knoll; aluminum tablet stamped "8594 SLAK"	8,583.954
Brighton Hotel, 1.9 miles northwest of 300 feet north of Big Cottonwood Creek, 50 feet north of road, at clearing, in granite bowlder 6 by 6 by 5 feet; aluminum tablet stamped "8044 SLAK"	8,034.730
Brighton Hotel 4.0 miles northwest of, 250 feet north of creek, 60 feet north of edge of road at Wilson's sawmill, in large granite bowlder; aluminum tablet stamped "7451 SLAK"	7,441.477

Salt Lake City south along Denver & Rio Grande R. R. to Riverton.

Salt Lake City, southeast corner of Temple Street South and Third Street West, 13.12 feet west of saloon entrance in Railroad Exchange Hotel, 213.2 feet southeast of southeast corner of Oregon Short Line R. R. passenger station, 5 feet east of curb on Third and Temple streets, 18 feet south of curb on Temple Street South; iron post	4,259.400
Salt Lake City, in front of Denver & Rio Grande R. R. station; top of rail	4,225.7
Salt Lake City, 600 feet south of Utah Portland Cement Works, in base of milepost 38; spike with aluminum tag stamped "4225"	4,226.89
Salt Lake City, 2.8 miles south of, in base of milepost 39; spike with aluminum tag stamped "4225"	4,225.10
Salt Lake City, 3.9 miles south of, in base of milepost 40; spike with aluminum tag stamped "4233"	4,232.96
Salt Lake City, 4.7 miles south of, 600 feet north of milepost 41, east end of retaining wall of railroad at concrete bridge over small creek; aluminum tablet stamped "4239-1"	4,238.727
Salt Lake City, 5.9 miles south of, in base of milepost 42; spike with aluminum tag stamped "4256"	4,256.53
Salt Lake City, 6.9 miles south of, in base of milepost 43; spike with aluminum tag stamped "4276"	4,276.12
Cahoons, in front of station; top of east rail	4,284.9
Murray, 0.5 mile north of, in base of milepost 44; spike with aluminum tag stamped "4294"	4,294.099
Murray, 150 feet east of station, southwest corner of American Smelting & Refining Co.'s property, 5 feet west of flagman's cabin, in stone pier 12 by 12 inches; aluminum tablet stamped "4310-2"	4,309.793
Murray, 0.5 mile south of station, in base of milepost 45, spike with aluminum tag stamped "4318"	4,318.034
Murray, 1.5 miles south of, in base of milepost 46; spike with aluminum tag stamped "4332"	4,331.889
Murray, 2.5 miles south of, in base of milepost 47, spike with aluminum tag stamped "4348"	4,347.932
Midvale, 1,000 feet west of station, northeast corner of brick building used as boarding house, 150 feet east of intersection of Main and Center streets, 5 feet above ground; aluminum tablet stamped "4354-3"	4,353.762
Midvale, 0.5 mile south of, in base of milepost 48; spike with aluminum tag stamped "4360"	4,360.231
Midvale, 1.5 miles south of, in base of milepost 49, spike with aluminum tag stamped "4356"	4,355.865
Midvale, 2.5 miles south of, in base of milepost 50; spike with aluminum tag stamped "4372"	4,371.817

	Feet.
Midvale, 3.2 miles south of, northeast corner of concrete culvert 727A, 10 feet east of track; aluminum tablet stamped "4378-4"	4.378.345
Midvale, 3.5 miles south of, in base of milepost 51; spike with aluminum tag stamped "4380"	4,380.495
Midvale, 4.5 miles south of, in base of milepost 52; spike with aluminum tag stamped "4390"	4,390.225
Riverton, 150 feet north of station, west side of track, in base of telephone pole; spike with aluminum tag stamped "4409"	4,409.572
Riverton, 0.5 mile south of, in base of milepost 54; spike with aluminum tag stamped "4411"	4,411.001
Riverton, 1.5 miles south of, in base of milepost 55, spike with aluminum tag stamped "4417"	4,417.389
Riverton, 2 miles south of, 5 feet east of track, northeast corner of concrete culvert 722A; aluminum tablet stamped "4426-5"	4,425.968

STRAWBERRY VALLEY 30′ QUADRANGLE (SALT LAKE 1° QUADRANGLE).

Deep Creek west via Strawberry and Daniels creeks to Heber.

Deep Creek, 100 feet north of, 10 feet north of road, 400 feet west of intersection of road with Deep Creek, in large sandstone ledge; bronze tablet stamped "7300 SLAK" (the rim of this tablet has been chipped off by Indians)	7,300.848
Soldier Springs, 360 feet northwest of, in large sandstone ledge 200 feet north of road; bronze tablet stamped "7634 SLAK"	7,635.337
Coal Creek, 200 feet north of, 250 feet north of road in canyon on south slope of hill, in large sandstone ledge; bronze tablet stamped "7750 SLAK"	7,751.383
Strawberry Creek, 300 feet north of north fork of, 50 feet north of trail, in granite bowlder at mouth of draw; bronze tablet stamped "7775 SLAK"	7,776.519
Divide between Strawberry Creek and Daniels Creek, summit of, 250 feet north of trail, in sandstone bowlder; bronze tablet stamped "7994 SLAK"	7,995.567
Daniels Canyon, north side of road, west end of grade, at mouth of small draw; iron post stamped "7112 SLAK"	7,112.968
Daniels Canyon, 20 feet northeast of road, 150 feet southwest of creek, in small clearing, 3.8 feet southeast of canyon; iron post stamped "6580 SLAK"	6,581.565
Daniels Canyon, 3 miles south of mouth of, 400 feet east of creek, 15 feet east of road on bench; iron post stamped "6227 SLAK"	6,228.316
J. J. Howe's ranch, mouth of Daniels Canyon, 300 feet northeast of residence, 75 feet north of gate to, 20 feet northeast of road; iron post stamped "6018 SLAK"	6,020.276

COALVILLE 30′ QUADRANGLE (SALT LAKE 1° QUADRANGLE).

Kimball via Wanship, Oakley, Knight's ranch, Hailstone, and Park City to Kimball.

Atkinson, SE. ¼ sec. 10, T. 1 S., R. 4 E., near railroad on side of hill opposite Paces ranch on Silver Creek; iron post stamped "6444 SLAK"	6,445.585
Wanship, sec. 20, T. 1 N., R 5. E., in northwest corner of Latter Day Saints' meetinghouse yard, iron post stamped "5860 SLAK"	5,861.548
Rockport, sec. 4, T. 1 S., R. 5 E., east side of wagon road at southwest corner of public hall; iron post stamped "6009 SLAK"	6,010.094
Peoa, sec. 23, T. 1 S., R. 5 E., in angle of fence at southwest corner of H. B. Williams yard, iron post stamped "6189 SLAK"	6,190.545
Oakley, 0.5 mile north of, sec. 19, T. 1 S., R. 6 E., southwest of crossroads; iron post stamped "6515 SLAK"	6,516.613
Marion, 0.5 mile north of, sec. 33, T. 1 S., R. 6 E., northeast of crossroads, beside main road; iron post stamped "6451 SLAK"	6,452.701
Kamas, sec. 14, T. 2 S., R. 6 E., southwest corner of Main Street schoolhouse grounds; iron post stamped "6473 SLAK"	6,473.919

	Feet.
T. 3 S., R. 6 E., near quarter corner on north side of sec. 4, at side of county road on Provo River, in front of James A. Knight's house; iron post stamped "6505 SLAK"	6,506.561
Hailstone, T. 2 S., R. 5 E., sec. 32, at junction of Provo River-Heber road with Park City-Heber road, 0.25 mile east of and across creek from Davis ranch, in front of schoolhouse; iron post stamped "5959 SLAK"	5,960.505
T. 2 S., R. 4 E., sec. 1, on summit of divide between Park City and Canyon leading down to Provo River, at point where wagon road crosses old railroad grade; iron post stamped "6726 SLAK"	6,727.642

Hailstone via Heber to Midway.

T. 3 S., R. 5 E., sec. 18, in southeast corner of Riverdale schoolhouse yard; iron post stamped "5714 SLAK"	5,715.685
Heber, in top of stone post near southeast corner of courthouse grounds; bronze tablet stamped "5593 SLAK"	5,594.334
Midway, sec. 35, T. 3 S., R. 4 E., at corner of Main Street and Park City road on lot owned by Wallace E. Potter; iron post stamped "5567 SLAK"	5,568.545

Wanship via Union Pacific R. R. to Coalville.

T. 2 N., R. 5 E., near quarter corner on north side of sec. 33, 136 feet east of highway crossing; iron post stamped "5708 SLAK"	5,709.641
Coalville, opposite southeast corner of station; top of east rail	5,571.4
Coalville, 0.5 mile northeast of, sec. 8, T. 2 N., R. 5 E., south meridian mark stamped "5607 SLAK"	5,608.103
Coalville, 0.6 mile northeast of sec. 8, T. 2 S., R. 5 E., north meridian mark stamped "5583 SLAK"	5,584.329

Coalville east along wagon road up Chalk Creek via Upton to Wyoming State corner.

T. 2 N., R. 5 E., sec. 11, on east side of county road, 300 feet south of bend in road, below mouth of "The Narrows;" iron post stamped "5746 SLAK"	5,747.459
T. 2 N., R. 6 E., sec. 5, at forks of main Chalk Creek road and road up south fork of Chalk Creek, across creek from and 0.5 mile northwest of Huffman's ranch; iron post stamped "5938 SLAK"	5,939.396
Upton, 0.5 mile east of post office, sec. 26, T. 3 N., R. 6 E., at southeast corner of schoolhouse yard, north side of county road; iron post stamped "6182 SLAK"	6,183.318
T. 2 N., R. 7 E., sec. 4, 160 feet east of bridge across Chalk Creek, 175 feet southeast of Deming schoolhouse, south side of county road; iron post stamped "6451 SLAK"	6,452.256
T. 3 N., R. 7 E., sec. 35 at forks of main Chalk Creek road and East Canyon-Red Hole road, 40 feet east of Chalk Creek road and 100 feet north of Red Hole road, 200 feet below crossing of East Fork; iron post stamped "6712 SLAK"	6,713.094
T. 3 N., R. 8 E., sec. 20, 2 miles down canyon from Wyoming State corner, 125 feet southeast of log house; iron post stamped "6897 SLAK"	6,898.127
T. 3 N., R. 8 E., sec. 16, Wyoming State corner, at head of Chalk Creek, in red stone post; bronze tablet stamped "7150 SLAK EVAN"	7,150.847

Coalville north along Union Pacific R. R. to Echo.

Grass Creek, sec. 32, T. 3 N., R. 5 E., west side of county road, 0.5 mile north of station, in front of brick residence; iron post stamped "5486 SLAK"	5,487.577
Echo, T. 3 N., R. 4 E., sec. 24, east side of wagon road at south end of street, under high hill; iron post stamped "5465 SLAK"	5,466.393
Echo, in front of station, main line, Union Pacific R. R.; top of rail	5,460.0

Oakley east along wagon road up Weber Canyon.

	Feet.
T. 1 S., R. 6 E., sec. 12, at forks of main canyon road with road up south fork of Weber Canyon; iron post stamped “6787 SLAK”	6,787.692
T. 1 N., R. 7 E., sec. 31, at forks of main Weber River road and road leading over divide to south fork of Chalk Creek, across river from and about 1 mile northeast of George Wiles's ranch; iron post stamped “6983 SLAK”	6,984.443
T. 1 N., R. 7 E., sec. 26, at forks of road in main Weber Canyon with road leading up Smith and Moorehouse Canyon; iron post stamped “7308 SLAK”	7,308.807
T. 1 N., R. 8 E., sec. 30, 2 miles northeast of high timbered peak on south side of Weber River, 0.25 mile south of Weber River, 10 feet south of road, 200 feet south of large dark rock north of wagon road; iron post stamped “7607 SLAK EVAN”	7,608.305
T. 1 N., R. 8 E., sec. 21, 50 feet west of bridge over Weber River, at old bridge and ford on Larrabee's ranch, 0.5 mile south of Larrabee's house and log barn, about 150 yards northeast of small lake, rock on road south and west of river; bronze tablet stamped “7682 EVAN”	7,683.184
T. 1 N., R. 8 E., sec. 23, 100 feet north of old setting of sawmill, at foot of divide, about 3 miles west of Summit Pass over Uinta Mountains, at forks of wagon road to Holiday Park; iron post stamped “7855 EVAN”	7,856.540

Kamas east along Provo River to divide between South Fork and Soapstone Basin.

T. 3 S., R. 6 E., east side of sec. 12, 1.3 miles east of Woodland post office, 250 feet north of bridge across Provo River, 30 feet southwest of road; iron post stamped “6804 SLAK”	6,805.309
T. 3 S., R. 7 E., sec. 15, R. L. Jones's ranch, 250 feet northwest of house, between forks of road up east and west forks of Provo Creek, 300 feet east of Provo River; iron post stamped “7129 SLAK”	7,129.938
T. 3 S., R. 7 E., sec. 24, 0.5 mile southeast of Oor ranch, between forks of road, at base of grade, 0.5 mile north of South Fork of Provo River; iron post stamped “7522 SLAK”	7,523.348
T. 3 S., R. 8 E., about northeast corner of sec. 29, unsurveyed township, divide between South Fork of Provo River and Soapstone Basin, 70 feet south of road, in large sandstone bowlder; bronze tablet stamped “9285 SLAK”	9,286.359

HAYDEN PEAK 30′ QUADRANGLE (UINTA 1° QUADRANGLE).

Sec. 30, T. 3 N., R. 10 E., along upper Bear River and Yellow Creek valleys (part of circuit extended from Evanston, Wyo.).

T. 3 N., R. 10 E., sec. 30, east bank of Bear River, 0.2 mile above mouth of West Fork, 5 feet west of road; iron post stamped “8038 EVAN”	8,039.383
T. 3 N., R. 10 E., sec. 31, on West Fork of Bear River, 1 mile southwest of mouth, west side of wagon road, 500 feet northwest of river; iron post stamped “8106 EVAN”	8,107.560
T. 2 N., R. 10 E., sec. 9, 0.5 mile east of Bear River, 3.25 miles above mouth of West Fork, large white flint rock at intersection of roads; copper bolt stamped “8327 EVAN”	8,328.202
T. 2 N., R. 10 E., sec. 17, 180 feet east of mouth of East Fork of Bear River; iron post stamped “8330 EVAN”	8,330.694
T. 2 N., R. 10 E., sec. 20, 2 miles northeast of mouth of Stillwater Fork, 0.2 mile east of Bear River; iron post stamped “8418 EVAN”	8,419.241
T. 2 N., R. 10 E., sec. 32, 0.8 mile above mouth of Hayden Fork, 12 feet east of wagon road, 300 feet from two old cabins on east bank of stream; iron post stamped “8587 EVAN”	8,587.688

	Feet.
T. 1 N., R. 10 E., sec. 4, on Stillwater Fork of Bear River, 1.25 miles southeast of mouth of Hayden Fork, 10 feet west of wagon road, east side of river; iron post stamped "8661 EVAN"	8,662.580
T. 1 N., R. 10 E., sec. 15, on Stillwater Fork of Bear River, 3.6 miles southeast of mouth of Hayden Fork, east side of river; iron post stamped "8792 EVAN"	8,793.317
T. 1 N., R. 10 E., sec. 7, 3 miles from Bear River ford, west side of Hayden Fork, south of road junction; iron post stamped "8805 EVAN"	8,805.817
T. 1 N., R. 9 E., sec. 24, on Hayden Fork, 6 miles above its junction with Bear River, 12 feet east of wagon road, west side of fork, 2 miles above bridge; iron post stamped "9048 EVAN"	9,049.510
T. 1 N., R. 9 E., sec. 13, 3 miles southwest of Hayden Fork, 25 feet southeast of wagon road, 8 feet north of large splintered rock; bronze tablet stamped "9466 EVAN"	9,440.641
T. 1 N., R. 8 E., sec. 14, 3.5 miles southwest of Hayden Fork, 0.8 mile east of high divide between Hayden Fork and West Fork; iron post stamped "9555 EVAN"	9,529.838
T. 1 N., R. 9 E., sec. 15, 2 miles east of Summit Pass over range at head of Weber River, 2 miles north of Hayden Fork, top of divide between Hayden Fork valley and Deer Creek valley, 6 feet west of wagon road; iron post stamped "9960 EVAN"	9,935.252
T. 2 N., R. 9 E., sec. 33, 160 yards south of west branch of Deer Creek, in Deer Creek valley; iron post stamped "9000 EVAN"	8,975.362
T. 2 N., R. 9 E., sec. 19, 1.8 miles south of old Moss sawmill, about 0.1 mile west of West Fork of Deer Creek, 1 mile north of old setting of Moss sawmill, about 200 yards east of circular group of pines, 25 feet south of wagon road; iron post stamped "9460 EVAN"	9,435.024
T. 2 N., R. 9 E., sec. 17, 200 feet south of new Moss sawmill, 12 feet north of most southerly cabin in sawmill group; iron post stamped "9193 EVAN"	9,167.973
T. 3 N., R. 9 E., sec. 31, 21 feet west of Yellow Creek, on road over divide to Deer Creek valley and sawmill, 45 feet west of road crossing of a west branch of Yellow Creek; iron post stamped "8237 EVAN"	8,212.031
T. 3 N., R. 9 E., sec. 18, 15 feet east of junction of Yellow Creek road and road leading off it to Bear River, 40 rods west of Yellow Creek, 3 miles southeast of emigrant road crossing of Yellow Creek, 200 yards northeast of long quaking aspen grove on west side of road, about 0.5 mile west of long bare-topped hill across creek; iron post stamped "7608 EVAN"	7,583.153

Divide at head of Weber River over pass and down to head of Weber River.

T. 1 N., R. 9 E., sec. 8, 1 mile northeast of pass at head of Weber River, 300 yards north of lake, 100 feet north of small spring by lone balsam tree, in large rock 8 feet west of wagon road by rocky ravine; bronze tablet stamped "9533 EVAN"	9,508.468
T. 1 N., R. 9 E., sec. 17, 0.25 mile south of high, round-topped, bare hill, 200 yards south of abandoned coal mine, top of divide near head of Bear River; iron post stamped "9989 EVAN"	9,964.306
T. 1 N., R. 9 E., sec. 18, 0.25 mile north of pass over divide near head of Weber River, 0.8 mile north of high bald-topped rocky peak with many rock slides on east side, on top of green bald hill, just north of pass near head of Weber River; iron post stamped "10402 EVAN"	10,403.444
T. 1 N., R. 9 E., sec. 18, 0.2 mile west of summit of divide, 5 feet south of road to Weber River and valley, 1 mile north of middle one of three high rocky peaks, in rock; bronze tablet stamped "9834 EVAN"	9,834.841

	Feet.
T. 1 N., R. 9 E., sec. 18, 1 mile west of Summit Pass over Uinta Mountains, about 0.5 mile southwest of rough ledge of yellow rocks above pine grove, 12 feet south of wagon road down Weber River; iron post stamped "9222 EVAN"	9,223.367

Divide between Big Muddy Creek and Blacks Fork south to Fish Lake, thence east and north along Blacks Fork to mouth of west fork of Blacks Fork of Green River.

T. 3 N., R. 11 E., sec. 25, 1.7 miles northwest of sawmill on Fish Creek, at forks of old and new roads, in heavy pine timber, 300 feet southwest of park, large granite bowlder; aluminum tablet stamped "9615 EVAN"	9,616.389
T. 2 N., R. 11 E., sec. 1, 950 feet southeast of Fish Lake, 20 feet east of road in timber, 300 feet southeast of log hut, in large bowlder; aluminum tablet stamped "9762 EVAN"	9,763.437
T. 2 N., R. 12 E., sec. 5, 3 miles southeast of Fish Lake, 1.25 miles below intersection of Fish Lake road and Blacks Fork road, at road forks, in bowlder beside mound of rocks; aluminum tablet stamped "9081 EVAN"	9,081.976
T. 3 N., R. 12 E., sec. 28, 0.8 mile north of forks of Blacks Fork, 40 feet east of road, 500 feet north of small slough or park, 150 feet west of river, on bank, in large bowlder; bronze tablet stamped "8816 EVAN"	8,817.152

Mouth of east fork of Blacks Fork east over divide to Smith Fork.

T. 3 N., R. 12 E., sec. 36, at summit and east edge of divide between Blacks Fork and Smith Fork, 10 feet north of road; iron post stamped "9900 EVAN"	9,900.495

East fork of Blacks Fork of Green River to Two Baldys.

East fork of Blacks Fork, 800 feet southeast of junction of east and west forks of, 750 feet above ford, at right of wagon road, in small park, in large bowlder; bronze tablet stamped "9363 EVAN"	9,363.940

Divide between south fork of Provo River and Soapstone Basin, east to Wolf Creek.

Old sawmill site, upper side of Soapstone Canyon, 175 feet southeast of road to Rhodes Canyon, near small gulch or drain in open country, in large limestone ledge; bronze tablet stamped "9390 SLAK"	9,391.127
Rhodes Canyon, west side of, 5 feet from edge of timber, in large granite bowlder; bronze tablet stamped "9383 SLAK"	9,383.708

GILBERT PEAK 30′ QUADRANGLE (UINTA 1° QUADRANGLE).

West Fork of Smith Fork at old steel sawmill southeast to Gilberts Creek, thence south to Two Baldys.

West Fork of Smith Fork River, 400 feet west of, 500 feet northwest of ford of old steel sawmill site; iron post stamped "9373 EVAN"	9,373.505
Gilbert Meadows, 1.5 miles south of south end of, 100 feet south of edge of small park in pine timber, near trees blazed and marked all around, in large bowlder; bronze tablet stamped "9905 EVAN"	9,906.378
Gilbert Meadows, 4.94 miles south of, in small saddle on divide, between east and west forks of Smith Fork, 4 miles N. 65° W. of Gilbert Peak, 125 feet due east of small lake, in rock; bronze tablet stamped "10690 EVAN"	10,691.121
Two Baldys, saddle between, about 4 miles due west of Gilbert Peak, divide between Blacks Fork and Smith Fork, in large bowlder; bronze tablet stamped "11428 EVAN"	11,429.322

Gilbert Meadows via south side of China Lake to west branch of Henrys Fork.

Gilbert Meadows, 1 mile east of, top of divide between east and west fork of Smith Fork, 10 feet north of road to China Lake, near mound of rock, in large bowlder; bronze tablet stamped "9938 EVAN"	9,938.582

	Feet.
China Lake, 0.23 mile outheast of, 200 yards west of Conger cabin, 10 feet north of road, 400 yards west of east fork of Smith Fork, in large bowlder; bronze tablet stamped "9401 EVAN"	9,402.071
China Lake, 2.3 miles east of, top of divide between Henrys Fork and Smith Fork, 150 feet east of forks of blazed trails, in large bowlder; bronze tablet stamped "10203 EVAN"	10,203.696

RED CREEK 30′ QUADRANGLE (UINTA 1° QUADRANGLE).

Wolf Creek southeast down Du Chesne River to upper crossing of Heber road.

Wolf Creek, 0.5 mile west of, northeast of junction of west fork of Wolf Creek, 75 feet north of road, in large granite bowlder; bronze tablet stamped "7305 SLAK"	7,306.238
Du Chesne River, 0.25 mile east of, 100 feet east of edge of bench, 200 feet southwest of trail, in large granite bowlder; bronze tablet stamped "6988 SLAK"	6,978.485
Du Chesne River, 0.25 mile east of, 300 feet east of trail, at point of red sandstone cliffs, in large sandstone ledge; bronze tablet stamped "6857 SLAK"	6,858.391
Indian Farms, 0.25 mile south of, 20 feet east of trail, 500 feet east of Du Chesne River; iron post stamped "6624 SLAK"	6,624.842
Du Chesne River, 0.25 mile east of upper crossing of road to Heber, in west face of large sandstone ledge 9 feet across, 0.2 mile east of road fork, 150 feet west of base of sandstone ridge in sagebrush flat; point on ledge (tablet removed by Indians)	6,428.580

Du Chesne River at upper crossing south via Heber road to Deep Creek.

Du Chesne River and Red Creek, divide between, on south side of Dry Canyon (commonly known as "Nigger Heaven"), in sandstone ledge, 50 feet north of road; bronze tablet stamped "6851 SLAK"	6,852.683
Du Chesne River, 7.5 miles south of, 30 feet north of Heber road, in sandstone ledge on small divide; bronze tablet stamped "6717 SLAK"	6,718.476
Red Creek, 3.5 miles northeast of, on east slope of divide, 250 feet south of road, 0.8 mile east of forks of road to Fort Du Chesne and upper crossing, in north end of long sandstone ridge; bronze tablet stamped "6560 SLAK"	6,561.361
Red Creek, 1,000 feet east of, south side of road ascending to terrace, in sandstone bowlder 7 by 9 by 8 feet; bronze tablet stamped "6553 SLAK"	6,553.852
Red Creek and Current Creek, top of divide between, 1.25 miles east of Current Creek and 50 feet north of old trail over divide, in south face of large sandstone ledge 10 by 10 by 8 feet; bronze tablet stamped "7104 SLAK"	7,105.002
Current Creek and Deep Creek, divide between, 10 feet to right of road in large sandstone ledge; bronze tablet stamped "7393 SLAK"	7,394.910

Upper crossing east down Du Chesne River.

Du Chesne River, 3.5 miles southeast of upper crossing of, 100 yards north of first ford across river, 60 feet east of road; iron post stamped "6268 SLAK"	6,258.214
Rock Creek, 300 yards east of, 0.25 mile east of mouth of, north edge of Tabby farm, south of road near fence; iron post stamped "6029 SLAK"	6,030.199

THEODORE 30′ QUADRANGLE (UINTA 1° QUADRANGLE).

Rock Creek down Du Chesne River to Lake Fork bridge.

Rock Creek, 3 miles southeast of, 500 feet east of Du Chesne River, 25 feet east of trail; iron post stamped "5900 SLAK"	5,901.255

	Feet.
Rock Creek, 6.8 miles south of, 0.25 mile east of Du Chesne River, at forks of road; iron post stamped "5789 SLAK"	5,790.640
Du Chesne bridge, 300 feet east of, at forks of road over Blue Bench, 3.5 miles above Strawberry Creek; iron post stamped "5648 SLAK"	5,638.547
Theodore, mouth of Strawberry Creek, 100 feet east of Du Chesne River, at point of ridge, forks of roads to "Nigger Heaven" and up Du Chesne River; iron post stamped "5517 SLAK"	5,507.763
Indian Canyon, 1.25 miles west of, 50 feet north of road, 500 feet north of river, on first bench, 0.25 mile west of point of timber; iron post stamped "5378 SLAK"	5,368.288
Du Chesne River, 300 feet north of, on side of hill at point where road goes over bench to Lake Fork, in sandstone ledge; bronze tablet stamped "5314" SLAK"	5,304.779
Lake Fork bridge, 100 feet east of, at mouth of Lake Fork, on north side of road; iron post stamped "5117 SLAK"	5,117.934

Lake Fork bridge and Du Chesne River northwest along road to upper crossing of Du Chesne River.

Lake Fork bridge, 3.1 miles northwest of, 500 feet west of road, 0.25 mile west of river, 200 feet north of small knoll, on large sandstone ledge; bronze tablet stamped "5170 SLAK"	5,171.144
Lake Fork bridge, 6.20 miles northwest of, 300 feet east of road and fence at Red Caps farm, on northwest end of long sandstone ridge; bronze tablet stamped "5348 SLAK"	5,349.363
Blue Bench, east edge of, 15 feet north of road, 11 miles northwest of Lake Fork bridge; iron post stamped "5950 SLAK"	5,951.498
Blue Bench, 3 miles west of, about center of east edge, 10 feet south of road, 0.25 mile south of lone bunch of cedars; iron post stamped "5989 SLAK"	5,990.444

Mouth of Lake Fork east along road toward Fort Du Chesne.

Du Chesne bridge, 1.8 miles northeast of, 4 miles east of Lake Fork bridge, on edge of second bench, 30 feet north of road to Fort Du Chesne; iron post stamped "5150 EVAN"	5,124.215

MARSH PEAK 30′ QUADRANGLE (ASHLEY 1° QUADRANGLE).

Point near Burnt Fork, Wyo., to Vernal, thence southwest via Halfway Hollow and Fort Du Chesne to Lake Fork bridge.

Burnt Fork, Wyo., 4 miles south of post office, in Utah, 0.5 mile west of Birch Creek, 6 feet north of road, in large flat bowlder; bronze tablet stamped "7537 EVAN"	7,511.861
Hills ranch, 2 miles southeast of, 250 feet east of east road to Vernal on side of hill, 0.5 mile east of Zeke Edwards' sawmill, in sandstone ledge; bronze tablet stamped "7896 EVAN"	7,870.977
Carter dugway, top of, 20 feet west of road, 12 miles southeast of Burnt Fork, in limestone ledge; bronze tablet stamped "8760 EVAN"	8,734.529
Lodgepole Creek, 0.34 mile south of, top of divide between Lodgepole Creek and Sheep Creek drainage, 400 feet north of Sheep Creek canal, 25 feet east of road, in limestone bowlder; bronze tablet stamped "8772 EVAN"	8,746.109
Sheep Creek, 750 feet south of, top of ridge, at edge of large park, 40 feet west of road, in large bowlder; bronze tablet stamped "8682 EVAN"	8,656.646
Beaver Creek, 75 feet north of, at southeast end of park, in head of small canyon, 300 feet southeast of Sheep Creek, 4 feet north of road, in ledge of sandstone; bronze tablet stamped "8477 EVAN"	8,451.465
Icy Hill dugway, center of, 6 feet west of road, 0.9 mile south of Carters Creek, in sandstone ledge; bronze tablet stamped "8250 EVAN"	8,224.825

	Feet.
Young Springs, 300 feet north of, east of ford, 12 feet south of road, in large bowlder; bronze tablet stamped "8419 EVAN"	8,393.838
Summit of Uinta Mountains, 3.7 miles south of Young Springs, 4 feet east of road, in sandstone ledge; bronze tablet stamped "9893 EVAN"	9,866.949
Pat Carl sawmill, 4 miles southeast of summit, 300 feet north of sawmill set, 15 feet north of road, in large bowlder; bronze tablet stamped "9589 EVAN"	9,563.784
Oakes sawmill, 0.25 mile south of, 300 feet east of Trout Creek, 15 feet south of road, in large bowlder; bronze tablet stamped "9312 EVAN"	9,286.365
Old Government sawmill, 0.3 mile south of, in south end of Government Park, at intersection of old corduroy road, in sandstone rock 6 by 4 by 3 feet; bronze tablet stamped "9132 EVAN"	9,106.594
Taylors Canyon, top of hill, south of road, 30 feet west of road, 2.85 miles southeast of Government sawmill, 1.2 miles north of Dippens, in large sandstone bowlder; bronze tablet stamped "9008 EVAN"	8,982.638
Dodds cabin, 1.3 miles southeast of, 19 miles northwest of Vernal, 10 feet east of road, in aspen timber, in large bowlder; bronze tablet stamped "8781 EVAN"	8,755.921
Ashley dugway, foot of, 14 miles north of Vernal, 30 feet east of road, in sandstone bowlder 8 by 8 by 5 feet; bronze tablet stamped "7960 EVAN"	7,933.889
Ashley Hill, foot of, 30 feet west of road, in cedars, 12 miles north of Vernal, in sandstone ledge; aluminum tablet stamped "6616 EVAN"	6,590.429
Spring Creek, 300 feet west of, 2.5 miles south of Ashley Hill, 5 feet west of road, in sandstone ledge; aluminum tablet stamped "6125 EVAN"	6,099.617
William Gibson's ranch, 2.6 miles northwest of, 20 feet north of road, in center of sand gulch, on sandstone ledge; aluminum tablet stamped "5744 EVAN"	5,718.326
William Gibson's ranch, center of sec. 2, T. 4 S., R. 21 E., east side of road, north side of gate, in front yard, edge of lawn, large sandstone shaft in ground; aluminum tablet stamped "5400 EVAN"	5,374.690

Sec. 17, T. 3 S., R. 21 E., southwest along road down Spring Creek to Ashley Creek, thence northwest along road up Dry Fork to Dry Fork village (double-rodded line).

T. 3 S., R. 21 E., S. ½ sec. 17, 300 feet west of Spring Creek, 2.5 miles south of Ashley Hill, 5 feet west of road, in sandstone ledge; tablet stamped "6098"	6,099.665
T. 3 S., R. 21 E., S. ½ sec. 30, near mouth of Dry Fork, 1,000 feet west of Brown's house, 200 feet from road fork, between roads from Vernal to Burnt Fork and Dry Fork, in bowlder; tablet stamped "5822"	5,823.722
T. 3 S., R. 20 E., SW. ¼ sec. 24, in Dry Fork Canyon, near mouth of Cinder Point Canyon, 10 feet south of road, on large bowlder	6,058.756
T. 3 S., R. 20 E., NW. ¼ sec. 23, 1 mile south of ranch house, in Dry Fork Canyon, on southwest side of road, 50 feet west of gate on northeast side of road, in sandstone ledge; tablet stamped "6296"	6,297.218
Dry Fork village, T. 3 S., R. 20 E., near schoolhouse, in bowlder; tablet stamped "6467"	6,468.728

Lonetree to Bridgeport (portion of line).[1]

Linwood, forks of main road and road to Linwood store; iron post stamped "6024"	6,013.528
Finches ranch, opposite, on summit; iron post stamped "5977"	5,975.833

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[1] For other parts of this line see Twin Buttes and Aspen Mountains quadrangles, Wyoming, and Browns Park quadrangle, Utah (p. 36).

BROWNS PARK QUADRANGLE (ASHLEY 1° QUADRANGLE).

Lonetree to Bridgeport (portion of line).[1]

	Feet.
Crouses ranch, 50 feet west of road, between residence and barn, in stone on bank; tablet stamped "5440"	5,438.635
Diamond Mountain, at foot of, in stone opposite road to spring; tablet stamped "5688"	5,689.163

VERNAL 30′ QUADRANGLE (ASHLEY 1° QUADRANGLE).

Vernal southwest along road to point 5.5 miles west of Fort Du Chesne.

Vernal, southeast corner of Ashley Cooperative Store building, in capstone; aluminum tablet stamped "5356 EVAN"	5,330.771
Vernal, 3 miles west of, at turn due west, in telephone road to Vernal and Fort Du Chesne, 5 feet west of corner of crossroads, in sandstone bowlder; aluminum tablet stamped "5477 EVAN"	5,451.421
Vernal, 5.9 miles west of, west side of open cut, top of divide between Ashley Valley and Halfway Hollow, in sandstone ledge; aluminum tablet stamped "5801 EVAN"	5,775.525
Vernal, 9.5 miles west of, 0.6 miles east of Halfway Hollow, 75 feet north of stage road, at point of sandstone ridge and dry wash; aluminum tablet stamped "5301 EVAN"	5,274.858
Vernal, 13 miles west of, 60 feet north of road, point of ridge 2.5 miles east of Halfway Hollow, in sandstone ledge; aluminum tablet stamped "5048 EVAN"	5,022.611
Halfway station, between Vernal and Fort Du Chesne, 200 feet south of forks of road, in large sandstone bowlder; aluminum tablet stamped "5030 EVAN"	5,004.169
Fort Du Chesne, 7.8 miles east of, 3.5 miles west of Halfway Hollow, 25 feet south of road, top of divide between Ute Fork and Halfway Hollow, in sandstone ledge; aluminum tablet stamped "5305 EVAN"	5,279.021
Fort Du Chesne, 4.1 miles east of, 1 mile east of Gilsonite mines on the Strap, base of sandstone cliff, in sandstone ledge; aluminum tablet stamped "5118 EVAN"	5,092.103
Fort Du Chesne, 10.9 feet south of point of southeast corner of quartermaster's office, 17.5 feet west of gate, in yard, in sandstone in ground; aluminum tablet stamped "5016 EVAN"	4,989.943
Fort Du Chesne, 5.5 miles west of, 225 feet north of road, at point of rocks; aluminum tablet stamped "5029 EVAN"	5,002.871

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[1] For other parts of this line see Twin Buttes and Aspen Mountains quadrangles, Wyoming, and Marsh Peak quadrangle, Utah.

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 490

MINERALOGICAL NOTES

SERIES 1

BY

WALDEMAR T. SCHALLER

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MINERALOGICAL NOTES—SERIES 1.

By WALDEMAR T. SCHALLER.

INTRODUCTION.

The miscellaneous papers here assembled are submitted as a report on the mineralogical work of research character conducted by the author in the chemical laboratory of the United States Geological Survey from 1905 to 1909. A similar report on earlier work (1903–1905) was published as Mineralogical Notes in Bulletin 262 (1905), on pages 121–144. Besides these papers, a report on an investigation of the mercury minerals of Terlingua, Tex., made in collaboration with Dr. W. F. Hillebrand, has been published as Bulletin 405, and the study of the tourmaline field of southern California has been continued.

Many of the minerals described in this Bulletin were received for identification and study from members of the United States Geological Survey. Some specimens, however, were received from persons not directly connected with the Survey, and a few were collected by the author in California. Several investigations could not be completed, owing to loss of material by fire on December 16, 1908. Certain of these interrupted studies will be pursued further as opportunity affords.

Some of the papers have, in substance, if not in the exact form here reproduced, already appeared in scientific journals. A number of these papers were originally written and published in conjunction with some of the geologists of the Survey. Full credit has been given to these geologists for their contributions, some of which have been slightly rearranged.

A report similar in character to this one and giving the results of studies extending from January, 1910, to July, 1911, has been prepared and submitted for publication as a Bulletin entitled "Mineralogical notes—series 2."

CHEMICAL COMPOSITION OF HULSITE AND PAIGEITE.

INTRODUCTION.

A description of two new borates, hulsite and paigeite, was published in 1908[1] by the writer in conjunction with Adolph Knopf, who discovered these minerals in Alaska. These borates contained both ferrous and ferric iron, magnesia, and a small amount of water. The boric acid was determined by distillation with methyl alcohol and subsequent weighing as lime borate, and although only a single determination was made for each mineral, the analyses footed up well and the ratios were so close to simple numbers that no doubt was entertained as to the correctness of the results obtained. Later, however, Prof. F. W. Clarke, chief chemist of the Geological Survey, informed the author that the determination of boric acid in minerals was being investigated by E. T. Wherry and W. H. Chapin, under the direction of Prof. Edgar F. Smith, of the University of Pennsylvania, and through the kindness of Prof. Smith the boric acid content of the new minerals was redetermined by methods devised by Wherry and Chapin.[2] By this redetermination it was found that the amounts first obtained were much too high. Another examination of the minerals, made to explain the discrepancy, showed the presence of tin in appreciable quantity in both minerals. It therefore became necessary to revise and extend the original analyses in order to fix definitely the composition of the minerals.

OCCURRENCE AND ASSOCIATION.

The occurrence of these borates and their relation to the tin deposits of Alaska have been described by Knopf. A summary of his description, together with brief mention of the associated minerals, follows.

The Alaskan tin deposits of known economic importance, which are limited to the extreme western part of the Seward Peninsula, about 100 miles northwest of Nome, are genetically associated with granitic intrusives which have invaded limestones of Paleozoic age. Along the margins of the granite bosses an intense pneumatolytic contact metamorphism has frequently been produced and a considerable variety of minerals developed. The largest granite boss of the region is that of Brooks Mountain, and the most energetic contact action is displayed along its periphery. Tin deposits also occur in connection with a smaller intrusive a few miles south.

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[1] Knopf, A., and Schaller, W. T., Two new boron minerals of contact metamorphic origin: Am. Jour. Sci., 4th ser., vol. 25, 1908, p. 323.

[2] Determination of boric acid in insoluble silicates: Jour. Am. Chem. Soc., vol. 30, 1908, p. 1687.

On the northeast flank of Brooks Mountain a prospect cut has been opened on an exposure of contact metamorphic minerals occurring in marmorized limestone 10 feet from the granite contact. Examination of this deposit showed hulsite, often intergrown with magnetite and vesuvianite, in considerable abundance. In the hand specimen taken from this exposure brown-green vesuvianite, magnetite, hulsite, and brown garnet occur scattered through a matrix of coarse white calc-spar. Occasionally some fluorite is visible. The characteristic forms of vesuvianite are *a*{100}, *m*{110}, *f*{120}, *c*{001}, *p*{111}, *t*{331}. Less prominent forms are *h*{130}, *δ*{113}, *i*{112}, *b*{221}. Among rare and somewhat doubtful ones are {150}, {180}, {1.10.0}, *v*{151}, and a few others. The angles measured are given in the table below.

Forms and angles for vesuvianite.

Letter.	Symbol.	Reflection.	Size of face.	Measured.		Calculated.	
				φ	ρ	φ	ρ
				° ′	° ′	° ′	° ′
a	100	Fair....	Large..........	0 00	90 00	0 00	90 00
c	001	Fair....	Medium........	....	0 00	....	0 00
(?)	1.10.0	Poor...	Line face.......	5 49	90 00	5 43	90 00
(?)	180	Poor...	Line face.......	7 13	90 00	7 08	90 00
(?)	150	Poor...	Line face.......	10 47	90 00	11 19	90 00
h	130	Poor...	Line face.......	18 26	90 00	18 26	90 00
f	120	Poor...	Line face.......	26 14	90 00	26 34	90 00
m	110	Fair....	Medium........	45 00	90 00	45 00	90 00
v	151	Poor...	Minute..........	10 01	69 47	11 18	69 57
δ	113	Poor...	Line face.......	45 00	14 20	45 00	14 13
i	112	Poor...	Line face.......	45 00	20 54	45 00	20 49
p	111	Fair....	Large..........	45 00	37 17	45 00	37 14
b	221	Poor...	Narrow........	45 00	57 03	45 00	56 40
t	331	Poor...	Narrow........	45 00	66 42	45 00	66 19

The forms {1.10.0}, {180}, and {150} are too doubtful to warrant their establishment as well defined without additional confirmation. On the Alaskan mineral, they form the merest striae, and the close agreement in angles for {1.10.0} and {180} may be accidental. When the vesuvianite is treated with fluorite mixture, it gives a distinct boron flame, and as it contains 0.89 per cent B_2O_3 is regarded as belonging to the variety wiluite. The magnetite shows *o*{111}, *m*{311}, *a*{100}, and *d*{110} with *om* large and *ad* small. The angles are shown below.

Forms and angles for magnetite.

Symbol.	Measured.	Calculated.
	° ′	° ′
$a \wedge m = 001 \wedge 113$	25 20	25 14
$a \wedge o = 001 \wedge 111$	54 42	54 44
$a \wedge d = 001 \wedge 101$	45 06	45 00

The characteristic features of hulsite are its strong metallic luster, black color, good prismatic cleavage, and tendency toward tabular development. Its surface weathering is almost identical with that of magnetite, and it may, on casual inspection, easily be confounded with that mineral. The tabular individuals of hulsite vary in thickness from a fraction of a millimeter to a little more than a centimeter, so far as known. Under the microscope it is absolutely opaque, and appears dark black in reflected light.

Thin sections show that magnetite is often intimately intergrown with the hulsite, from which it may be distinguished by its bright metallic reflection.

The other mineral, paigeite, which was found at Brooks Mountain in loose blocks and at Ear Mountain, 40 miles northeast, in place, is a lustrous, coal-black mineral of foliated appearance. A thin section of the matrix from Brooks Mountain shows vesuvianite, calcite, hedenbergite, a small amount of biotite, and arsenopyrite in sporadic grains. The paigeite is abundant, and occurs in many places in capillary or trichite-like forms transfixing the various other associated minerals. At Ear Mountain a granite intrusion has produced an extensive development of contact metamorphosed limestones, especially lime silicate hornfels, some of which is flecked with paigeite and chalcopyrite. Under the microscope this variety of hornfels is seen to consist of a confused intergrowth of calcite, zonally banded tourmaline, pleochroic in tones of blue and brown, vesuvianite, fluorite, and zoisite, with accessory phlogopite, chalcopyrite, and magnetite. Paigeite fibers and matted aggregates are embedded in the various constituent minerals, especially in the tourmaline and calcite.

NOTES ON CHEMICAL EXAMINATION.

GENERAL STATEMENT.

These borates, hulsite and paigeite, which are similar in composition, contain ferrous and ferric iron, magnesia, tin, water, and boric acid. In solutions of samples in hydrochloric acid, silica, alumina, and lime, derived from the gangue, also appear.

The results of considerable work performed on these minerals herein presented are not altogether satisfactory. A complete revision of all the chemical data is highly desirable, but such revision, in order to make determinations exact, would require new material, in considerable quantities, free from gangue.

The present investigation was carried on under great disadvantages, for the amount of material for analysis was insufficient and the presence of foreign matter in very appreciable quantities could not be avoided. Less than a gram of hulsite free from magnetite was available, and only a few grams of paigeite could be obtained in approximately pure condition. In consequence, solutions to various questions that developed after some of the analyses had been completed could not be worked out, owing to lack of material. Individual samples of the minerals, moreover, differed somewhat in composition, owing to the nature of the gangue and to isomorphous replacements in the minerals themselves. All these conditions, which were brought out as the analyses progressed, served to render the results unsatisfactory.

A brief description of the gangue and a somewhat more detailed account of certain of the analytical methods employed will be given in order to present properly the evidence on which are based the formulas here proposed for hulsite and paigeite.

THE GANGUE.

The material here designated as gangue comprises those minerals—vesuvianite, arsenopyrite, and several others—which were associated with the borates and could not be separated from them. The amount of gangue present in the specimens available for analysis ranged from 10 to 30 per cent. Hulsite is in nearly all specimens mixed with magnetite, and nonmagnetic hulsite seems to be extremely rare. In the preparation for the new analyses all the material available was broken up and the hulsite was picked out with a hand lens. The greater part of the hulsite—that in which magnetite was present—was then removed with a magnet, leaving less than a gram of nonmagnetic and magnetite-free material, which, however, contained appreciable amounts of vesuvianite, calcite, and other gangue minerals. This sample is referred to later as hulsite sample No. 3.

The samples of paigeite comprised several pieces about an inch thick. The mineral is coal black and massive and of laminated or radiating fibrous structure. The gangue, with which it is intimately mixed, is stained brown, presumably by ferric oxide. Samples of the black paigeite were so selected as to exclude all visible gangue; but a microscopic section of one sample showed that the paigeite occurs as small fibers and irregular masses as inclusions in the gangue minerals and it therefore contains considerable extraneous matter—generally about 20 per cent.

A small amount of arsenopyrite is always present, even though none is visible to the eye, and appears amid the main mass of whitish residue after the paigeite is dissolved out by hydrochloric acid. Microscopic examination indicates that this gangue or whitish residue is for the most part vesuvianite. Calcite and magnetite seem, in general, to be absent from the massive paigeite samples, but, in addition to the arsenopyrite, tourmaline and fluorite may be present in varying but small quantities. When the paigeite is dissolved out by hydrochloric acid, these substances remain behind and may be filtered off.

Certain conditions, however, indicate that the gangue as a whole is considerably attacked and dissolved by the acid. First, more than 3 per cent of silica was found in the hydrochloric acid solution of one sample of paigeite. Whether the silica has isomorphously replaced the tin in the borate or whether it comes from the gangue is not definitely known, but the latter supposition is by far the most plausible. The excessive values for gravimetric R_2O_3 determinations, which are always several per cent higher than the total amount of iron, are doubtless due to silica and alumina derived from the gangue. Confirmation of the presence of alumina in the solution, however, would not necessarily point to the gangue as its source, for it might come from the iron borate as an isomorph of Fe_2O_3. Second, some of the gangue, as shown by the microscope, is stained yellow by iron chloride. Hydrochloric acid does not dissolve the stain, and this fact seems to show that the gangue either consists in part of, or is coated by, a layer of colloidal matter able to retain the iron chloride. Crystallized vesuvianite, which is unattacked by acid, is not able to retain the iron chloride stain so tenaciously. Third, when the gangue or insoluble residue was heated at 110° to constant weight it retained considerable water, which was not given off until the crucible was heated to a low red heat. If the gangue were unattacked, its weight dried at 110° should be but little, if any, more than what it weighs on being ignited. The percentages of the insoluble gangue of paigeite, first dried at 110° to constant weight and then carefully ignited, follow:

Percentage of insoluble gangue in paigeite.

	No. 5.	No. 6.	No. 7.
Insoluble gangue dried at 110°	20.24	20.60	19.29
Insoluble gangue ignited	17.32	17.51	16.99

The presence in the paigeite solution of considerable calcium, which was shown by qualitative tests on small pieces of the purer mineral to be almost absent from some samples of the borates, also indicates the extent to which the gangue is attacked. The silica and bases thus entering into solution seriously complicate the interpretation of the analyses.

When vesuvianite and arsenopyrite, the chief constituents of the gangue of paigeite, are ignited, they decrease somewhat in weight. Arsenopyrite changes in accordance with the following reaction: $2FeAsS + 10O = Fe_2O_3 + As_2O_3 + 2SO_2$. The weight of the ferric oxide, which remains after the reaction, is about half that of the arsenopyrite; therefore half the weight of the arsenopyrite is lost in ignition. Vesuvianite loses only about 2 per cent water when heated, a loss which, if the amount of material in the paigeite sample were 15 per cent, would amount to 0.3 per cent. The amount of arsenopyrite in the original samples of paigeite is about 2 per cent, and when the gangue is ignited there is a loss of half this amount plus the 0.3 per cent loss of vesuvianite, making a total loss of 1.3 per cent. This amount must therefore be added to the final value of the ignited residues of paigeite, as has been done in the analyses given in this paper.

The amount of calcite in the gangue is generally very small and was not determined in these investigations. The per cent was largest in hulsite sample No. 3. Magnetite was removed from all the samples of hulsite except No. 2, a magnetite-hulsite mixture.

METHODS OF ANALYSES.

Ferrous iron is present in both borates in large amount, and was determined by a modification of Pratt's method, which has been shown by W. F. Hillebrand to give reliable values.[1] Both new borates here described dissolve readily in hydrofluoric acid, so that no difficulty was experienced in making the ferrous-iron determinations. The hulsite powder was always coarser than 100 mesh and the paigeite powder coarser than 60 mesh, so that very little, if any, oxidation of the ferrous iron resulted from the grinding. That such oxidation occurs and may be extensive has recently been shown by Mauzelius.[2] Oxidation due to grinding is considerable on the FeO contained in these borates, for in paigeite the amount for FeO falls from 44 per cent in <20> 60-mesh material to 39 per cent in the same material finely ground. The data given below indicate the results of grinding paigeite and a similar borate, ludwigite, from Hungary.

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[1] The analysis of silicate and carbonate rocks: Bull. U. S. Geol. Survey No. 305, 1907, p. 138.

[2] Sveriges Geol. Undersökning, Yearbook 1, No. 3, 1907. Consult Chem. Abstract, 1907, p. 2861, for an abstract of this article. See also Hillebrand, W. F., The influence of fine grinding on the water and ferrous-iron content of minerals and rocks: Jour. Am. Chem. Soc., vol. 30, 1908, p. 1120.

Oxidation of ferrous iron on samples of paigeite.

	Pratt's method.	Cooke's method.
	Per cent.	*Per cent.*
FeO (<40> 100 mesh):		
At beginning of test	43.87	43.91
After grinding 1 hour	41.38	40.88
After grinding 2 hours	40.23	39.98
After grinding 7 hours	39.78	39.59
FeO (<20> 40 mesh):		
At beginning of test	44.30	
After grinding 1 hour	42.24	
When finely ground	39.39	

A sample of ludwigite containing about 16 per cent of ferrous iron gave the following results on the oxidation of FeO by grinding:

Oxidation of ferrous iron on ludwigite (two determinations by Pratt's method).

	1	2
	Per cent.	*Per cent.*
FeO (<20> 40 mesh):		
At beginning of test	15.84	15.88
When crushed to 120 mesh	15.50	15.53
When finely ground	15.43	15.34

The oxidation of ludwigite is not nearly so great as that of paigeite, the remarkable oxidation of which is probably largely due to the presence of an abundance of gangue material, such as vesuvianite and arsenopyrite, much harder than the borate itself.

The amount of ferrous oxide given in the analyses of hulsite and paigeite also includes that of the vesuvianite present, but this amount is probably so small that it may be neglected. The vesuvianite has not been analyzed, but the ferrous iron in it is doubtless less than 1 per cent. The arsenopyrite present had no effect on the determination of ferrous oxide, for the mineral particles were so large that the arsenopyrite remained undissolved in the hydrofluoric-acid solution.

The total iron content of the borates, and thereby the amount of ferric iron present in them, was determined in the usual manner by dissolving the precipitated R_2O_3 in sulphuric acid or by fusion of the ignited precipitate with sodium pyrosulphate and subsequent titration with potassium permanganate. By fusing the ignited precipitate the silica present could be recovered and determined.

The amount of tin was determined by precipitating it with H_2S from the HCl solution of the minerals and by weighing it as oxide. The easy solubility of both the minerals in cold dilute acid indicates that the tin occurs as some form of stannic acid. Qualitative tests showed that the tin was present in solution in the stannic condition.

Boric-acid determinations were made in the original analyses by distilling with methyl alcohol. It is not known why high results were obtained, for the method is more likely to give low values. The method adopted for the reanalyses of the borates, that proposed by Wherry,[1] was first tested on samples of known B_2O_3 content. The values here given do not agree closely, because of the small amount of material available and the varying amount of gangue present in the samples.

The percentage of water was determined by heating the mineral to be tested (size $<20>$ 60 mesh) in a glass tube and weighing the water directly in a portion of that tube (Penfield's method).

As the determination of total water was made on coarse material the amount of hygroscopic water in the sample was reduced to a minimum. What increase in the water content is caused by grinding these borates is not known, but experiments with ludwigite, a mineral of analogous composition, show that a very considerable amount of water is taken up. (See p. 15.) Total water determinations for such minerals as these borates must, therefore, to be of value, be made on coarse material, such as was used in these investigations. It is believed that the water content given for these minerals is an essential part of their composition, rather than hygroscopic or accessory water, but definite proof of this hypothesis is lacking, and future work may show the water associated with these two minerals to be extraneous. Hillebrand,[2] who has made a study of the effect of grinding on the ferrous-iron content of minerals, called the writer's attention to these conditions, which served to explain the varying results first obtained on paigeite for ferrous iron.

The same general method was followed in the analyses. The powdered or coarsely crushed sample was treated in a beaker with a small amount of HCl and allowed to stand some hours. Platinum dishes should not be used, as the large amount of iron chloride and possibly also tin chloride readily attacks and dissolves the platinum. Solution of the finely crushed borate samples was usually complete in a few hours. Solution of the coarser samples was hastened by gentle warmth. The solution must not be allowed to boil, on account of volatility of $SnCl_4$ in steam. Under the conditions described the arsenopyrite is not attacked, though partial solution of the vesuvianite occurs. After filtration and ignition of the gangue (see p. 13), H_2S was conducted into the diluted solution, the tin sulphide filtered off and determined, the solution boiled, the iron oxidized, and the analysis continued as usual. A determination of the alkalies was made in one sample, 0.54 per cent of K_2O and 0.70 per cent of Na_2O being found. As the operations were made in glass vessels and many reagents had been added to the solution, these values, even though small in quantity, probably do not represent alkalies originally in the mineral. Traces of manganese and titanium are present in the samples, but the following elements and radicals were never found, though several qualitative tests for them were made: Ba, Bi, Cd, Zn, rare earths, Cb, Ta, Li, Mo, Te, W, U, Zr, V, F, sulphates, phosphates, and chlorides.

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[1] Determination of boric acid in insoluble silicates: Jour. Am. Chem. Soc., vol. 30, 1908, p. 1687.

[2] Jour. Am. Chem. Soc., vol. 30, 1908, p. 1120.

HULSITE.

CRYSTALLOGRAPHY.

Hulsite always occurs in crystalline form, either as small crystals about 1 millimeter in diameter or as large tabular masses, extending several centimeters and showing well developed prismatic cleavage. The crystals, though they may be complete, are always uneven, and the faces dull and rough, so that no measurements could be obtained from any of the natural faces. Inspection with a hand lens shows that these crystals are often rectangular, and as hulsite is provisionally considered orthorhombic these rectangular prisms consist of the three pinacoids. Sometimes the crystals are bounded by the prism faces and the basal pinacoid, though it is not always possible to decide whether the prisms are natural crystal faces or whether they are due to cleavage. Often one pair of prism faces becomes much larger than the other pair. The cleavage parallel to the prism is good, and measurements of three such cleavage angles gave the values:

$m \wedge m''' = 57° 44', 57° 38', 57° 33'$. Average value $57° 38'$. Assuming that hulsite is orthorhombic, the crystallographic elements become:

$a : b : c = 0.5501 : 1 : ?$
Forms : $a\{100\}$, $b\{010\}$, $c\{001\}$, $m\{110\}$.

Many of the crystals are twinned, one individual being turned about 120° to the other and the two basal pinacoids remaining in the same plane. They are also often grouped in parallel position, especially when the individual crystals are elongated parallel to a prism face.

GENERAL PROPERTIES.

Hulsite is black, but when free from inclosed magnetite has a greenish, brownish, or reddish tinge. Many of the smaller crystals are covered with a brownish coating, probably limonitic in character. The streak is black and the luster generally submetallic, though that of the pure mineral tends rather to vitreous, like hornblende. The hardness is about 3 and the density is 4.31. The cleavage is good, being prismatic parallel to $m\{110\}$. Hulsite is readily soluble in HCl and HF, but dissolves in other acids with some difficulty. It gives off water in a closed tube, and fuses quietly before the blowpipe to a dull black slag, giving a slightly green flame. When heated with potassium bisulphate and fluorite, it gives a persistent green color to the flame.

The composition of sample No. 2 (see beyond) was found by calculation to be approximately as follows:

Vesuvianite	2.2
Hulsite	80.6
Magnetite	17.2
	100.0

The density of this mixture is 4.438. If the density of vesuvianite is taken as 3.40 and that of magnetite as 5.17, the density of hulsite is found by calculation to be 4.31.

CHARACTER OF SAMPLES.

The sample of hulsite first submitted for chemical investigation was apparently homogeneous. It was, however, strongly magnetic, and though it was suspected that it consisted of a mixture of a nonmagnetic borate with magnetite, various tests failed to show the presence of the latter mineral. When powdered finely and suspended in water, the particles were still attracted by the magnet, and none of the many chemical tests attempted led to a separation of the magnetite from the borate. After the analytical work on this sample had been finished, some specimens of hulsite collected in previous years were tested and found to be nonmagnetic. These specimens showed that the earlier ones contained admixed magnetite and a careful examination of all of the samples on hand showed the very common presence of magnetite in varying amounts included in the hulsite.

The few specimens that were nonmagnetic and free from magnetite seemed to weather more easily than the others, and several of them were more or less altered to a limonitic substance, so that the amount of fresh material on hand was very small. After the presence of tin in hulsite was established, all the specimens at hand were again gone over for material for reexamination, but only a very small quantity of hulsite free from magnetite was obtainable.

Three samples of hulsite were obtained and analyzed. Sample No. 1 consisted of about half a gram of hulsite free from magnetite, which was crushed into grains of <60> 100 mesh size and partially analyzed, only ferrous and ferric iron, magnesia, and the insoluble matter being determined. The value given for the magnesia content is doubtless high, for a little lime was probably present and, if so, was determined as magnesia. A part of the magnesia, too, was derived from the gangue. Sample No. 2 consisted of about a gram of material at first supposed to be homogeneous, but later found to consist of a mixture of hulsite and magnetite with a small amount of gangue. Tin was not determined in either sample, and the value for boric acid in sample No. 2 was furnished by Wherry and Chapin.[1] Sample No. 3 was obtained by reexamining all the available material and picking out a small amount of nonmagnetic hulsite mixed with considerable gangue. The relatively large amount of gangue soluble in acid complicated the interpretation of the results.

ANALYSES AND RATIOS.

The analysis of the first sample yielded the following results:

Partial analyses of hulsite, sample No. 1.

	1	2	Average.
FeO	33.27	....	33.27
MgO	....	10.17	10.17
Fe_2O_3	....	....	17.83
Total iron as Fe_2O_3	54.40	54.20	....
Insoluble	....	10.00	10.00
B_2O_3,SnO_2,H_2O	....	....	....

The ferrous iron and magnesia are doubtless not present in any definite ratio, but vary reciprocally, so that hulsite may be considered as a mixture of a ferrous with a magnesian borate. In the above analysis the ratio of FeO : MgO is about 9 : 5. Ferrous iron and magnesia are probably isomorphous in hulsite as well as in paigeite, and similarly in the related borate ludwigite. An analysis of ludwigite from Montana shows this isomorphism particularly well, for this mineral contains but little ferrous iron, while that from Hungary contains about 15 per cent. (See p. 32.)

The ratios in sample No. 1 are shown in the following table:

Ratios of average analysis of hulsite, sample No. 1.

FeO	0.462	=6.63
MgO	.254	
Fe_2O_3	.108	=1.00

The ratio of RO : Fe_2O_3 as given by the analysis is 6.63 : 1, but the true value is probably better represented by the ratio 6 : 1, for, as already stated, the magnesia value is doubtless high.

The second sample, in which the hulsite was mixed with magnetite, gave the following results on analysis:

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[1] Loc. cit.

Analyses of hulsite, sample No. 2.

	1	2	3	4	5	Average.
FeO	34.48	34.35				34.44
MgO	8.60	8.83	8.36	8.12		8.48
Fe_2O_3						27.64
Total iron as Fe_2O_3	66.24	67.08	65.70	65.42	65.32	
H_2O	1.63	1.68				1.66
B_2O_3					10.44	10.44
Insoluble	2.25	1.97	2.24	2.48		2.24
SnO_2						

The ratios obtained from the above analyses, as given, are:

Ratios of average analysis of hulsite, sample No. 2.

FeO	0.479
MgO	.212
Fe_2O_3	.173
H_2O	.092
B_2O_3	.149
SnO_2	.....

Analysis of sample No. 3 shows the ratio of B_2O_3 to Fe_2O_3 to be 3 : 2. From this ratio the amount of magnetite present in sample No. 2 can be calculated, for the amount of ferric iron entering into the composition of the borate can be easily determined, and the remainder must therefore belong to the magnetite. When the proper amount of FeO required to form $FeO.Fe_2O_3$ is deducted from the ratios, they reduce to figures representing the composition of the magnetite-free hulsite.

Ratios showing composition of hulsite free from magnetite.

	Ratios from analysis.	Ratios of magnetite.	Ratios of hulsite.	
FeO	0.691	−0.074	0.617	12.4
MgO				
Fe_2O_3	.173	− .074	.099	2.0
H_2O	.092		.092	1.9
B_2O_3	.149		.149	3.0
SnO_2			.....	....

The ratios from the above analyses give as the formula for pure hulsite $12.4RO.\ 2.0Fe_2O_3.\ 1.9H_2O.\ 3.0B_2O_3+?SnO_2$.

The results obtained from the analyses of sample No. 3 are given below. Considerable insoluble gangue was present, but magnetite was entirely absent. The results shown under the heading 1a were obtained from analysis of a small sample of less pure material. They are not taken into the average, and are of value chiefly because they confirm the figures given for tin in the other analyses. The amount of ammonia precipitate in 1a was not determined, since it was used for various qualitative tests, and the calcium precipitate was accidentally lost. The higher value for the amount of boric acid is taken in the average instead of the mean of the two values, for the second determination is believed to be low.

Analyses of hulsite, sample No. 3.

	1a	1	2	3	Average.
FeO				27.71	27.71
MgO	3.62		4.13	4.45	4.29
CaO		7.98	9.82	9.54	9.11
Fe_2O_3					15.21
Total iron as Fe_2O_3			46.30	45.67	
SnO_2	6.13	6.85	7.15	7.20	7.07
B_2O_3		9.20	8.27		9.20
Insoluble	27.42	19.92	17.52	18.44	18.63
$H_2O, CO_2, SiO_2, Al_2O_3$			diff.		8.78
					100.00

The following ratios were calculated from the figures for the average analysis:

Ratios of average analysis of hulsite, sample No 3.

FeO	0.385	$\}=10.47$
MgO	.107	
Fe_2O_3	.095	= 2.02
SnO_2	.047	= 1
B_2O_3	.131	= 2.79

Analyses of paigeite samples reported in this paper indicate the amount of calcium oxide derived from the gangue. Where the insoluble matter is approximately 15 per cent, the calcium-oxide content is about 4 per cent. If this ratio remains fairly constant, there should be in the above analysis of hulsite sample No. 3 about 5 per cent of lime derived from the gangue, leaving approximately somewhat less than 4 per cent of CaO, which may belong to the borate mineral. If this CaO enters into the composition of the borate, the ratio of (FeO, MgO, CaO) to Fe_2O_3 would become 11.9 : 1, or nearly 12 : 1. The analysis of sample No. 3 shows the formula of hulsite to be either $10\frac{1}{2}RO.2Fe_2O_3.SnO_2.3B_2O_3 + ?H_2O$ or $12RO.2Fe_2O_3.SnO_2.3B_2O_3 + ?H_2O$.

DISCUSSION OF FORMULAS.

From the results of the analyses of the three samples of hulsite, as given, there are derived the following partial formulas for the mineral:

Partial formulas for hulsite.

Sample.	RO.	Fe_2O_3.	SnO_2.	B_2O_3.	H_2O.
No. 1...	13.2	2.0	....	....	....
No. 2...	12.4	2.0	....	3.0	1.9
No. 3..	10.5	2.0	1.0	2.8	....
	12.0	2.0	1.0	2.8	....

From this incomplete compilation the most probable formula is $12RO.2Fe_2O_3.1SnO_2.3B_2O_3.2H_2O$ or $(Fe,Mg)_{12}Fe_4SnB_6H_4O_{31}$. Hulsite can hardly be considered a borate of iron (ferrous and ferric), tin and magnesia, for the bases are present in overwhelming amount; therefore the ferric iron may be considered to be present as an acid, playing the same rôle as the borates. On the basis of this assumption the formula may be written $R''_9(BO_3)_6.R''_3[Sn(OH)]'''H_3(FeO_3)_4$.

The tin in hulsite occurs in a condition so easily soluble in dilute acid that it is probably present in some form of stannic acid. The possible presence of stannic acid, however, in combination with boric and possibly some iron acids, leads to complications which can not well be discussed at present.

PAIGEITE.

GENERAL DESCRIPTION.

Specimens of paigeite from Brooks Mountain are coal black and lustrous. The mineral has a laminated appearance. No distinct crystals were visible, but the entire mass has a crystalline appearance and in thin sections is seen to be composed of innumerable hair-like needles, which often form radiating groups. The hardness of paigeite is about 3, and the density is 4.78. Both color and streak are coal black. It dissolves readily in HCl and HF, and resembles hulsite in its pyrognostic properties.

The density of sample No. 1 was determined as 4.544. Calculation shows the density of pure paigeite to be 4.78, in accordance with the following analysis of the sample:

Component minerals and densities of paigeite, sample No. 1.

	Densities.	Per cent of sample.
Vesuvianite....................	3.40	19
Arsenopyrite....................	6.0	2
Paigeite........................	4.78	79
	....	100

CHARACTER OF SAMPLES.

Three different samples of paigeite were prepared and analyzed. The amount of gangue varied only slightly as compared with the large variations encountered in hulsite. The first analysis was made on sample No. 1; on this sample no determination of tin was made, and the value given for B_2O_3 is that determined by Wherry and Chapin. The other samples were prepared from specimens at hand. Sample No. 2 consisted of finely ground material, and consequently the value given for FeO may be somewhat low. The material of sample No. 3 was coarser, but otherwise very similar in character to No. 2.

ANALYSES AND RATIOS.

The results of the analyses of sample No. 1 are shown below.

Analyses of paigeite, sample No. 1.

	1	2	3	4	Average.
FeO	43.91	44.30	45.82	43.87	44.48
MgO	1.70	1.22	1.39		1.44
Fe_2O_3					16.72
Total iron as Fe_2O_3	66.26	65.95	66.22		
H_2O	2.03				2.03
B_2O_3				9.83	9.83
Insoluble	15.55	15.76	15.65		15.65

The amounts of SnO_2 and of its soluble gangue were not determined.

Ratios from average analysis of paigeite, sample No. 1.

FeO	0.618	=31.1
MgO	.036	
Fe_2O_3	.105	= 5
H_2O	.113	= 5.4
B_2O_3	.140	= 6.7

From the above analysis, the incomplete formula derived for paigeite is $31.1RO.\ 5.0Fe_2O_3.\ 5.4H_2O.\ 6.7B_2O_3 + ?SnO_2$.

Analyses of the second sample yielded the following results:

Analyses of paigeite, sample No. 2.

	1	2	3	Average.
FeO	40.82			40.82
MgO	2.02	2.01	2.10	2.04
CaO	4.28	4.31	3.81	4.13
Fe_2O_3	18.19	19.34	18.48	18.67
Total iron as Fe_2O_3	63.54	64.69	63.83	
SnO_2	3.15	3.14	3.26	3.18
B_2O_3	9.10			9.10
Insoluble	16.18	15.74	16.38	16.10
SiO_2,Al_2O_3,H_2O (difference)				5.96
				100.00

If all the lime is considered as resulting from solution of the gangue, the ratios deduced from the above analyses are:

Ratios of average analysis of paigeite, sample No. 2.

FeO	0.567	=29.4
MgO	.051	
Fe_2O_3	.117	= 5.6
SnO_2	.021	= 1
B_2O_3	.130	= 6.2
H_2O	......	....

These ratios give the following formula, which is incomplete in respect to the water content: $29.4RO.5.6Fe_2O_3.1SnO_2.6.2B_2O_3+?H_2O$.

Evidence that the gangue was considerably dissolved by HCl led to direct determinations of the silica and alumina in analyses of the third sample, with the following results:

Analyses of paigeite, sample No. 3.

	1	2	3	Average.
FeO	34.68	34.86	35.52	35.02
MgO	2.25	1.89	2.22	2.12
CaO	8.97	8.56	8.84	8.79
Fe_2O_3	14.69	14.84	15.18	14.90
Total iron as Fe_2O_3	53.22	53.57	54.62	....
SnO_2	2.77	2.86	[a] 2.76	2.80
B_2O_3	....	6.71	7.16	6.94
Insoluble	18.62	18.81	18.29	18.57
SiO_2	3.28	2.78	3.25	3.10
Al_2O_3	2.51	2.41	2.09	2.34
H_2O, etc. (difference)	....	....	....	5.42
				100.00

[a] A fourth determination of SnO_2 gave 2.97 per cent.

In the ratios derived from the above analysis, which are given herewith, the CaO, SiO_2, and Al_2O_3 are excluded as belonging with the insoluble matter of the gangue.

Ratios of average analysis of paigeite, sample No. 3.

FeO	0.486	=28.5
MgO	.056	
Fe_2O_3	.093	= 4.9
SnO_2	.019	= 1
B_2O_3	.099	= 5.2
H_2O	......	....

As in one of the hulsite analyses, the amount of calcium oxide is considerably higher in sample No. 3 than in sample No. 2, a fact that seems to indicate that some of the lime belongs to the borate. Only 1.57 per cent of CaO would be needed to raise the ratio of FeO+MgO+CaO to SnO_2 from 28.5 : 1, as given above, to 30 : 1, and this small amount of lime is therefore considered as belonging to the borate. The ratios obtained above are 28.5 or 30.0 RO. $4.9Fe_2O_3$. $1SnO_2$. $5.2B_2O_3 + ?H_2O$.

DISCUSSION OF FORMULAS.

The following formulas are deduced for paigeite from the above three series of analyses:

Formulas for paigeite.

Sample.	RO.	Fe_2O_3.	SnO_2.	B_2O_3.	H_2O.
No. 1...	31.1	5.0	....	6.7	5.4
No. 2...	29.4	5.6	1.0	6.2	....
No. 3..	28.5	4.9	1.0	5.2	....
	30.0	4.9	1.0	5.2	....

Averages of these figures give as the most probable formula for paigeite, and the one proposed for the mineral, $30FeO.5Fe_2O_3.1SnO_2.6B_2O_3.5H_2O$.

The above formula is complex and yields a high ratio of FeO to SnO_2, but no other interpretation of the analyses can be made. It is not impossible that paigeite may be a mixture of two or more closely related minerals, but only the unusual composition indicates such a mixture. The constant small percentage of tin oxide shows the material to be essentially different in ratios from the corresponding hulsite. The occurrence of the mineral in wavy, lamellar masses or in fine radiating fibers, its intense shiny black color, and the marked tendency shown in thin sections by the individual fibers and masses to fray out at the ends into a bunch of very thin fibers serve to differentiate this mineral from hulsite, which never shows any indication of fibrosity.

An alternative interpretation of the composition of paigeite is that it is a mixture of hulsite and a fibrous borate. Subtracting from the formula of paigeite the constituents of hulsite in the amounts necessary to include all the tin, the following results are obtained:

Paigeite..................	30 FeO	5 Fe_2O_3	1 SnO_2	6 B_2O_3	5 H_2O
Equivalent of hulsite...	12 FeO	2 Fe_2O_3	1 SnO_2	3 B_2O_3	2 H_2O
Remainder.............	18 FeO	3 Fe_2O_3	....	3 B_2O_3	3 H_2O

This remainder may be written $6FeO.Fe_2O_3.B_2O_3.H_2O$.

Should future investigation prove this interpretation correct, the material now called paigeite would consist of a mixture of 1 part of hulsite and 3 parts of the borate $6FeO.Fe_2O_3.B_2O_3.H_2O$, to which the name paigeite could then be referred. It is most reasonable, however, from the evidence at hand, to regard paigeite as homogeneous and as having the composition ascribed to it.

CHEMICAL COMPOSITION OF JAMESONITE AND WARRENITE.

INTRODUCTION.

Knowledge of the difficult group of sulpho-salts has, in the last few years, been much enriched by the labors of English mineralogists, particularly those of the British Museum. Spencer, whose work has been especially notable, in a recent paper considers warrenite, which was described as a new mineral by Eakins, a former member of the U. S. Geological Survey laboratory, as identical with jamesonite, for which he proposes a new formula.[1]

This criticism naturally created considerable interest at the Survey laboratory, and at the suggestion of Prof. F. W. Clarke, the writer undertook a reexamination of the subject. W. F. Ferrier generously furnished for the investigation his collection of warrenite, consisting of over a dozen specimens, which agreed in general character with those in the British Museum, as described by Spencer.[2] The gangue of the specimens examined consists of pink rhodochrosite, in the cavities of which the felted aggregates of short and straight needles characteristic of the mineral occur.

As much of the felted material as possible was picked out. Though the bulk was large, the weight was inconsiderable; in fact, the quantity of material was entirely insufficient to warrant any chemical analysis. Press of routine work necessitated laying the problem aside for a time, and before more material could be separated from the gangue the specimens were practically ruined by fire on December 16, 1908. The loss precluded any chemical work being done, but some of the results obtained by review of previous work led to conclusions which may further contribute to knowledge of these minerals.

FORMULA OF JAMESONITE.

Spencer concluded that the most probable formula for jamesonite was $7(Pb_{\frac{4}{5}},Fe_{\frac{1}{5}})S.4Sb_2S_3$. If this be expanded, we obtain $Pb_{28}Fe_7Sb_{40}S_{95}$, a formula resembling so closely the simple formula $Pb_{28}Fe_7Sb_{42}S_{98}$, or $Pb_4FeSb_6S_{14}$, that inquiry was directed as to whether or not the latter might represent the composition of jamesonite. The suggestion that iron seems to be present in amount nearly constant (between 2 and 3 per cent) certainly seems to be justified by the analyses given. Spencer has selected from the literature of the subject those analyses of jamesonite made on material with characteristic and well defined physical properties, such as the basal cleavage. Since these are the only analyses that can be used, they are repeated below,[1] together with the values calculated for a new formula proposed for jamesonite, namely $4PbS.FeS.3Sb_2S_3$.

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[1] Spencer, L. J., Note on "feather ore;" identity of "domingite" (="warrenite") with jamesonite: Mineralog. Mag., vol. 14, 1907, p. 207; Analysis of crystallized jamesonite, idem, p. 310.

[2] Idem, p. 208.

Analyses of jamesonite.

	Calculated.	1	2	3	4	5	6	7	8	9	10
S	21.86	20.52	21.37	22.15	22.53	[23.01]	21.78	21.52	20.86	21.35	21.75
Sb	35.10	34.53	34.70	34.40	34.90	33.47	32.62	33.03	31.94	(a)	32.00
Pb	40.32	41.18	40.08	40.75	39.45	40.35	39.97	40.13	42.79	40.47	39.06
Fe	2.72	2.76	2.79	2.30	2.65	2.96	3.63	(a)	2.83	2.68	2.00
Cu	....	.26	.22	.13	.19	.21	....	....	1.01	.50	3.45
Zn	....	....	....	....	....	....	.42	.36	1.84	5.82	.62
Bi	....	....	....	....	....	....	1.06	....	....	....	....
Ag	....	.01	.13	....	....	....	....	....	....	....	1.34
As	....	....	....	....	....	....	....	....	....	....	.20
	100.00	99.26	99.29	99.73	99.72	100.00	99.48	....	101.27	....	100.41

a Not determined.

Copper and zinc in considerable quantities are present in the last three analyses, provided, of course, that the samples were pure, an assumption not necessarily true. These analytical figures are very close to the values calculated for the formula here proposed, and support that formula quite as much as the more complicated one of Spencer. Loczka has published an analysis[2] of "a felted aggregate of dark steel-gray fibers," which he refers to plumosite, and from which he calculated a formula identical with the one here proposed, namely $4PbS.FeS.3Sb_2S_3$. In abstracting Loczka's article Spencer states[3] that "the figures agree still more closely with the jamesonite formula, $7(Pb_{\frac{4}{5}}Fe_{\frac{1}{5}})S.4Sb_2S_3$," a statement hardly borne out by the facts. Loczka's analysis and the values calculated for Spencer's formula[4] $7(Pb_{\frac{4}{5}}Fe_{\frac{1}{5}})S.4Sb_2S_3$, and for the formula $4PbS.FeS.3Sb_2S_3$, appended for purposes of comparison, are given in the following table:

Loczka's analysis and values calculated for the two formulas.

Loczka's analysis.		$7(Pb_{\frac{4}{5}}Fe_{\frac{1}{5}})S.4Sb_2S_3$.	$4PbS.FeS.3Sb_2S_3$.
S	21.59	21.70	21.86
Sb	35.80	34.23	35.10
Pb	39.38	41.29	40.32
Fe	2.65	2.78	2.72
Mn	.12	....	....
Zn	.10	....	....
Cu	Trace.	....	....
Insoluble matter	.50	....	....
	100.14	100.00	100.00

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[1] Analyses 1 and 2 (Bolivian material), are by Prior; 3, 4, and 5 by Rose (1826, 1829); 6 and 7 by Schaffgotsch (1836); 8 and 9 by Rammelsberg (1849); 10 by Sievert (1873). For references see Mineralog. Mag., vol. 14, 1907, p. 313.

[2] Loczka, Josef, Analysis of plumosite from Felsobanya: Ann. musei Nat. Hungarici, vol. 6, 1908, p. 586.

[3] Jour. Chem. Soc., vol. 96, 1909, p. 153.

[4] The figures are calculated from the 1909 table of atomic weights and differ very slightly from those given by Spencer.

Loczka's analysis agrees more closely with the simple formula, which is certainly the one to be preferred. It is much to be regretted that Loczka did not state definitely whether the fibers were flexible or brittle, but from the analytical figures alone his analysis must be referred to jamesonite and not to plumosite.

The evidence herein cited gives ample support to the formula first given by Loczka and reached independently by the writer. The chemical formula for jamesonite may then be given as $4PbS.FeS.3Sb_2S_3$ (Loczka), while for plumosite the simpler composition $2PbS.Sb_2S_3$ (Spencer) holds, the two minerals being distinguished chemically by the respective presence and absence of iron.

COMPOSITION OF WARRENITE.

Spencer includes warrenite under jamesonite, and the analysis given by Eakins agrees well both with Spencer's and with Loczka's formulas, though the iron is nearly 1 per cent low. Spencer states[1] that "It was, however, determined that the needles (of warrenite) are brittle and not flexible. * * * This latter character indicates that the material must be referred to jamesonite." He further classifies "feather-ores" as flexible and brittle, all the latter being referred to jamesonite and the former either to zinckenite, plumosite, boulangerite, or meneghinite. His statement that the needles of warrenite are not flexible was not confirmed by an examination of the specimens at the writer's disposal, for many were so flexible that they could be bent double without breaking, and sprang back to their original position when released. Other needles, however, were decidedly brittle, and instead of bending always broke across the elongation. Warrenite, then, has both flexible and brittle needles, and Eakin's analysis shows it to consist of a mixture of jamesonite and zinckenite.

Eakin's analysis of warrenite, with ratios.

	Analysis.	Ratios. Jamesonite. Zinckenite.	Zinckenite ratios recalculated.
S	21.19	0.661=0.448+0.213	4.00
Sb	36.34	.302= .196+ .106	2.00
Pb	39.33	.190= .128+ .062	1.17
Fe	1.77	.032= .032+ .0	
Insol	.52		
	99.15		

The last column of ratios leads to the zinckenite formula, $PbS.Sb_2S_3$. The analysis of warrenite, then, shows it to consist of a mixture of about 2 parts of jamesonite with 3 parts of zinckenite.

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[1] Spencer, L. J., Note on "feather ore;" identity of "domingite" (="warrenite") with jamesonite: Mineralog. Mag., vol. 14, 1907, p. 207.

LUDWIGITE FROM MONTANA.

OCCURRENCE AND ASSOCIATION.

The ludwigite here described was collected at Philipsburg, Mont., by Donald F. MacDonald, and was sent to the chemical laboratory of the survey for determination by F. C. Calkins. It is said to occur in metamorphosed limestone in connection with large bodies of magnetite. Examination of a thin section showed that a member of the olivine group was sprinkled throughout the ludwigite, and that a carbonate and a secondary fibrous mineral were also present in minute amounts.

The ludwigite forms small spherulites composed of radiating fibers of a very dark green or nearly black color, and resembles in its physical properties the original ludwigite from Hungary. With high magnification the fibers extinguish parallel and show a strong pleochroism, parallel to the elongation a sea green, and normal thereto a chestnut brown, with stronger absorption in the brown than in the green. The refractive index is much higher than 1.67. The olivine mineral has a mean refractive index of about 1.66, and cleavage sections parallel to $b(010)$ showing α and β have refractive indices lying between 1.65 and 1.66. The mineral must therefore be very low in ferrous iron, and is referred to forsterite. As no calcium was noted in the analysis, the carbonate is either magnesite or siderite.

ANALYSIS.

The sample free from magnetite, but containing a small quantity of forsterite and minute amounts of the colorless fibrous mineral and the carbonate, gave on analysis the following results, the figures in the last column showing the values with the forsterite and carbonate deducted and the analysis recalculated to 100 per cent.

Analyses of ludwigite from Montana.

	Analyses of ludwigite mixed with forsterite and carbonate.				Analysis of ludwigite.
	1	2	3	Average.	
FeO	6.12	5.53	5.74	5.79	7.27
MgO	39.09	38.60	39.42	39.04	33.78
Total iron as Fe_2O_3	36.33	36.01	....	....	....
Fe_2O_3	....	....	....	29.73	37.37
SiO_2	8.97	8.74	8.85	8.85	....
Al_2O_3	1.98	1.64	....	1.81	2.27
H_2O+	.97	....	....	.97	1.24
H_2O-	.91	.95	.85	.90	1.13
CO_2	.28	.43	....	.36	....
B_2O_3	13.48	....	....	13.48	16.94
				100.93	100.00

The ferrous iron was determined by a modification of Pratt's method,[1] the material used being finely ground. Experiments conducted by Hillebrand on samples of this mineral showed that the oxidizing effect of grinding on the ferrous iron was slight. The first value for alumina, 1.98 per cent, was obtained as the difference between the gravimetric determination of R_2O_3 and the subsequent volumetric titration of the iron with permanganate solution. The iron and aluminum chloride solution was repeatedly evaporated with methyl alcohol to expel all the boric acid. The second value, 1.64 per cent, was determined by precipitating the alumina by phenylhydrazine, as described by Allen.[2] As the two determinations agree fairly well, the presence of a small amount of alumina in the sample seems well confirmed. The higher result of the first case is probably due to retention of a small amount of boric acid. Whether the alumina belongs to the ludwigite or to one of the accompanying minerals is difficult to decide, but it has here been included in the borate. The boric acid content has also been determined by Wherry and Chapin,[3] who give as the average of their results 12.82 per cent B_2O_3, a value slightly lower than the one here given.

The water content, though small, is still of sufficient importance to merit consideration. Although no definite conclusion has been reached, it is believed that the greater part, if not all, of the water is not essential to the composition of the mineral. The determinations were made on finely ground material, which no doubt took up considerable water. A preliminary experiment on some ludwigite from Hungary gave the following values for the amount of water given off by the mineral when heated in a toluene bath at 110° in a current of dry air. Duplicate determinations were made, first on coarsely crushed material and then on another part of the same sample finely ground.

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[1] Hillebrand, W. F., The analysis of silicate and carbonate rocks: Bull. U. S. Geol. Survey No. 305, 1907, p. 138.

[2] Jour. Am. Chem. Soc., vol. 25, 1903, p. 421. See also Bull. U. S. Geol. Survey No. 305, 1907, p. 95.

[3] Wherry, E. T., and Chapin, W. H., Determination of boric acid in insoluble silicates: Jour. Am. Chem. Soc., vol. 30, 1908, p. 1691.

	(1)	(2)
Sample crushed <10> 20 mesh	0.09 per cent.	0.12 per cent.
Same finely ground	0.50 per cent.	0.52 per cent.

As some water may also have been furnished by the fibrous material, it seems justifiable to conclude that a large part, if not all, of the water reported in the analysis is extraneous. It has been omitted in the consideration of the ratios deduced from the analyses.

DISCUSSION OF FORMULA.

Ratios calculated from the figures of the average analysis are as follows:

Ratios of average analysis of ludwigite.

	Ratios.	Forsterite and magnetite deducted.	Ludwigite.
MgO	9760	8195	$\left.\begin{matrix}\\\end{matrix}\right\}7532=4\left\{\begin{matrix}3.57\ \mathrm{MgO.}\\0.43\ \mathrm{FeO.}\end{matrix}\right.$
FeO	804		
Fe_2O_3	1858		$\}2035=1.08.$
Al_2O_3	177		
SiO_2	1475	1475	
CO_2	82	82	
B_2O_3	1926		1926=1.02.

The ratios agree well with the formula generally given for ludwigite, $4RO.Fe_2O_3.B_2O_3$. The high water content obtained by Whitfield,[1] on Hungarian material, 3.62 per cent, is substantiated neither by the analysis of the Montana mineral given above nor by the analysis of Hungarian ludwigite described in this paper, but each sample yields about 1 per cent of water which can not as yet be proved foreign to the mineral and may ultimately be shown to be one of its essential constituents. If the water given off above 107° (H_2O+) be considered as essential to the mineral, a formula of about the proportions, $RO:Fe_2O_3:B_2O_3:H_2O = 16:4:4:1$ would result.

Although the ratios agree well with the general formula of ludwigite, the amount of ferrous iron is too small for the formula $FeO.Fe_2O_3.3MgO.B_2O_3$, even if all the ferrous iron in the analysis is referred to ludwigite and none either to forsterite or to the carbonate. These data indicate that the formula for the Montana ludwigite may be written .57MgO. .43FeO. Fe_2O_3. 3MgO.B_2O_3, thus showing an isomorphous mixture of a *ferrous* ferric magnesian borate with a *magnesian* ferric magnesian borate, the latter being in excess.

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[1] Whitfield, J. E., Natural borates and borosilicates: Am. Jour. Sci., 3d ser., vol. 34, 1887, p. 284.

Analyses by Ludwig and Sipöcz and by Whitfield are confirmed by the analysis published in this paper in the respect that the Hungarian mineral approximates closely to the definite formula FeO.Fe_2O_3. 3MgO.B_2O_3. Only one analysis by Ludwig and Sipöcz hows a slight deficiency in the ferrous iron.

The mineral from Montana, however, is very much lower in ferrous iron and correspondingly higher in magnesia, the ratios of B_2O_3:Fe_2O_3:FeO+MgO remaining constant. This condition supplies sufficient evidence of the existence of a magnesian ferric borate MgO.Fe_2O_3.3MgO.B_2O_3 free from ferrous iron, not yet found in nature in the pure state, but preponderant in the Montana ludwigite, in which it is present in isomorphous mixture with the corresponding ferrous ferric magnesian borate to the extent of 57 per cent. If some of the ferrous iron present in the sample belongs to the forsterite or to the carbonate, the percentage of the magnesian borate would be still greater.

LUDWIGITE FROM HUNGARY.

For comparison with the Montana mineral, an analysis was made of a sample of ludwigite from Hungary. The results of the quantitative analysis, made on the finely radiating black mineral, is as follows:

Analyses of ludwigite from Hungary.

	1	2	3	Average.
FeO	15.84	15.68	15.80	15.84
MgO	28.88	28.88		28.88
Total iron as Fe_2O_3	53.35	52.74	53.72	
Fe_2O_3				35.67
H_2O-	.50	.52		.51
H_2O+	.78	.86		.82
CO_2	.90			.90
Insol	.32	.40		.36
B_2O_3	[17.02]			[17.02]
				100.00

The ratios from the average analysis give, after the CO_2 is deducted, together with sufficient MgO to form magnesite, the formula $FeO.Fe_2O_3.3MgO.B_2O_3$, as shown below.

Ratios of average analysis of ludwigite from Hungary.

FeO	0.220	0.99
MgO	.702	3.06
Fe_2O_3	.223	1.00
B_2O_3	.243	1.09
CO_2	.020	....

SUMMARY.

The isomorphous relation of FeO and MgO in ludwigite can be well shown by bringing together the available analyses, which also show how closely the mineral from Hungary agrees with the calculated values for the pure ferrous-iron ferric magnesian borate. The first column gives the calculated values for $FeO.Fe_2O_3.3MgO.B_2O_3$, the second, third, fourth, and fifth the analyses of the Hungarian mineral, and the sixth that of ludwigite from Montana.

Analyses of ludwigite.

	$FeO.$ $Fe_2O_3.$ $3MgO.$ $B_2O_3.$	Ludwigite from Hungary analyzed by—				Ludwigite from Montana.
		Ludwig and Sipöcz.	Schaller.	Whitfield.	Ludwig and Sipöcz.	
	1	2	3	4	5	6
FeO	17.01	17.67	15.84	15.78	12.46	7.27
MgO	28.61	26.91	28.88	30.57	31.69	33.78
Fe_2O_3	37.81	39.29	35.67	37.93	39.92	37.37
Al_2O_3	....	....	....	....	....	2.27
B_2O_3	16.57	15.06	[17.02]	12.04	16.09	16.94
MnO	....	Trace.	....	.16	Trace.	....
H_2O-	....	....	.51	3.62	....	1.13
H_2O+	....	....	.82		....	1.24
SiO_2	....	....	.36	....	....	....
CO_2	....	....	.90	....	....	....
	100.00	98.93	100.00	100.10	100.16	100.00

The last analysis by Ludwig and Sipöcz (No. 5 above) shows a slight replacement of the ferrous iron by magnesia, which has been carried out to a much larger extent in the mineral from Montana. All new occurrences of ludwigite should be carefully examined chemically, as the possibility of the existence of the ferrous-iron-free magnesian borate is strongly indicated by the above analyses.

BISMITE FROM NEVADA.

OCCURRENCE AND PHYSICAL PROPERTIES.

According to Ransome,[1] bismite occurs in the Goldfield district of Nevada in the January, Combination, and Sandstorm mines, and probably also in other mines, as minute, pearly scales of brilliant and almost metallic luster, which suggest at first glance delicate and untarnished crystals of native silver. This mineral, identified by him as bismite, is limited to the oxidized zone, is generally accompanied by limonite, and is not uncommonly associated with rich ore. It occurs as single glittering scales or specks on the walls of cavities in spongy limonite or rusty ledge matter, as delicate frost-like films on the same materials, and as spongy aggregates with quartz. In the last-named form it is clearly pseudomorphous after bismuthinite, the material having consisted originally of a mass of bismuthinite prisms held together by a siliceous gangue. The prismatic structure of the bismuthinite is retained as hollow casts in the quartz, lined or partly filled with scales of bismite. The single scales are doubtless also derived from bismuthinite, but migration has taken place either during or after oxidation, and the bismite scales do not occupy the exact position of the parent needles of bismuthinite.

Natural crystals of bismite do not appear to have been found hitherto, and, inasmuch as the mineral has been assigned to the orthorhombic system in Dana's and Hintze's mineralogies on the basis of Nordenskiöld's work on artificial crystals in 1860 and 1861, considerable interest attaches to the Goldfield occurrences on account of the crystallinity of the material.

When examined under the microscope in gently powdered material, the crystals appear as thin colorless scales, with occasionally a suggestion of hexagonal outline. On account of their tenuity, it is rare that an edge view of a scale can be obtained. The larger flat-lying scales are dark in all positions between crossed nicols, and give a negative uniaxial figure with convergent light. There are no colored rings, and double refraction, apparently, is not great. The refractive index, on the other hand, is comparatively high—greater than that of anorthite. The mineral has a perfect basal cleavage and the scales, when viewed without the analyzing nicol, commonly show delicate interference colors, due to refraction and reflection at the surfaces of the exceedingly thin cleavage sheets.

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[1] Ransome, F. L., The geology and ore deposits of Goldfield, Nev.: Prof. Paper U. S. Geol. Survey No. 66, 1909, p. 121.

CRYSTALLOGRAPHY.

The minute, tabular crystals are too incomplete to make possible a determination of their geometrical form by crystallographic measurements alone. The uniaxiality and hexagonal outline of the crystals, the triangular markings on their bases, and the distribution of faces so far as known justify their provisional reference to the rhombohedral division of the hexagonal system.

The value of the *c* axis, derived in a manner presently to be described, is 0.5775. Seven faces are recognized—the base and one negative and five positive rhombohedra—and indications of two more positive rhombohedra appear. A brief description of these forms follows.

$c\{0001\}$. Always very large, even, and highly polished. When triangular markings or striæ are shown the faces parallel to these markings are taken as positive.

$o\{10\bar{1}6\}$. Occurs on two crystals as broad faces, giving, however, poor reflections. One face was considerably striated, giving two signals a degree apart.

$q\{10\bar{1}5\}$. Broad faces giving fairly good reflections.

$u\{10\bar{1}4\}$. Narrow faces, one striated with a fair reflection, and one as a line face giving a very poor reflection.

$k\{10\bar{1}3\}$. Usually as a line face, striated and giving a very poor reflection.

(?)$\{20\bar{2}5\}$. A doubtful face, narrow, giving no distinct signal.

(?) $d\{10\bar{1}2\}$. Another doubtful face, narrow, and giving no distinct reflection.

$y\{20\bar{2}1\}$. Line faces, giving exceedingly faint reflections.

$z\{01\bar{1}1\}$. The only negative rhombohedron observed. Very faint line faces, giving no reflection. Its negative position could be determined only on crystal No. 6.

The measurements of the forms are shown below.

Measurements of forms on bismite crystals.

Symbol.	Measured.				Calculated.	
	°	′	°	′	°	′
$c\wedge o=(0001):(10\bar{1}6)$	6	37	6	41	6	21
$c\wedge q=(0001):(10\bar{1}5)$	7	33	7	36	7	36
$c\wedge u=(0001):(10\bar{1}4)$	9	31	9	31	9	28
$c\wedge k=(0001):(10\bar{1}3)$	12	11	12	26	12	32
	13	18	13			
$c\wedge y=(0001):(20\bar{2}1)$	54		54		53	08
$c\wedge z=(0001):(01\bar{1}1)$	35		32½		33	42
Doubtful forms:						
$c\wedge ?=(0001):(20\bar{2}5)$	15		....		14	56
$c\wedge d=(0001):(10\bar{1}2)$	16	20	....		18	26

The value for the c axis was obtained from three measurements considered most accurate. The others gave values agreeing fairly well with the one adopted, as is shown in one of the following tables. The crystals were measured on the two-circle goniometer and the ρ angle for these forms is the angle between that form and the base. The value p_0 is obtained directly from the ρ angles and from the values for p_0, the c axis is readily calculated. The three best measurements are:

Three best values of p_0, bismite.

Crystal No. 1: $\rho\{10\bar{1}5\}=7^\circ\ 33'$; therefore $p_0=0.6627$
Crystal No. 4: $\rho\{10\bar{1}5\}=7^\circ\ 36'$; therefore $p_0=\ .6672$
Crystal No. 2: $\rho\{10\bar{1}4\}=9^\circ\ 31'$; therefore $p_0=\ .6706$

Average..........................=0.6668; $c=0.5775$

An average of the other measurements gave values closely agreeing.

Other values of p_0, bismite.

Crystal No. 3: $\rho\{10\bar{1}6\}=\ 6^\circ\ 37'$; therefore $p_0=0.6960$
Crystal No. 6: $\rho\{10\bar{1}6\}=\ 6^\circ\ 41'$; therefore $p_0=\ .7031$
Crystal No. 6: $\rho\{10\bar{1}4\}=\ 9^\circ\ 31'$; therefore $p_0=\ .6706$
Crystal No. 6: $\rho\{10\bar{1}3\}=12^\circ\ 11'$; therefore $p_0=\ .6477$
Crystal No. 4: $\rho\{10\bar{1}3\}=12^\circ\ 26'$; therefore $p_0=\ .6614$
Crystal No. 1: $\rho\{10\bar{1}3\}=13^\circ\ 18'$; therefore $p_0=\ .7102$

Average..........................=0.6815

The following measurements of faces giving no distinct reflections also showed close agreement:

Additional values of p_0, bismite.

Crystal No. 1: $\rho\{10\bar{1}3\}$ =12°–14° (average 13°); therefore $p_0=0.69$
Crystal No. 2: $\rho\{20\bar{2}5\}$?=15°; therefore $p_0=\ .67$
Crystal No. 1: $\rho\{10\bar{1}2\}$?=16°–20° (average 18°); therefore $p_0=\ .65$
Crystal No. 5: $\rho\{01\bar{1}1\}$ =35°; therefore $p_0=\ .70$
Crystal No. 6: $\rho\{01\bar{1}1\}$ =32½; therefore $p_0=\ .64$
Crystal No. 1: $\rho\{20\bar{2}1\}$ =54°; therefore $p_0=\ .69$
Crystal No. 6: $\rho\{20\bar{2}1\}$ =54°; therefore $p_0=\ .69$

The values for p_0 given in these tables show that the interpretation of the forms is the correct one.

Of the six crystals (all incomplete) that were measured, only two require special mention. Figure 1 is an orthographic projection of crystal No. 1, showing the trigonal distribution of the rhombohedra, and the triangular markings on the base. Figure 2 shows a similar projection of crystal No. 6, with a negative rhombohedron.

So uneven is the development of the faces of these crystals that no two faces of the same form are present on the upper half of a crystal. This feature is, however, due in part to the incompleteness of the crystals.

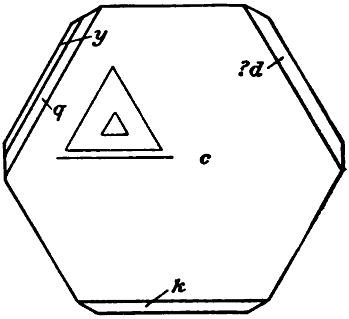

FIGURE 1.—Bismite crystal No. 1, orthographic projection.

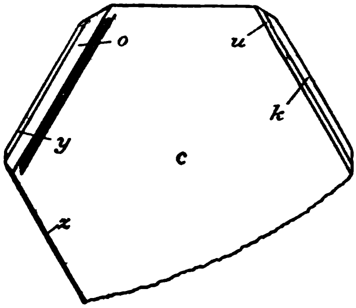

FIGURE 2.—Bismite crystal No. 6, orthographic projection.

CHEMICAL COMPOSITION.

The best material obtainable consisted of the spongelike aggregates with quartz, and this, on analysis, yielded the following results:

Analyses of bismite.

	1	2	3	Average.
Matter insoluble in HCl (mostly quartz gangue).	78.95	78.87	79.01	78.94
Bi_2O_3	17.29	17.00	16.84	17.04
H_2O (loss on ignition)	3.96	....	....	3.96
Fe_2O_3	.36	.50	.21	.36
				100.30

The phosphate, chloride, carbonate, and sulphate radicles, as well as vanadium, arsenic, calcium, magnesium, and the alkalies were absent.

The analysis shows that the mineral is either bismite or a hydrous oxide of bismuth. If it is the latter, the mineral is a new species (providing, of course, that Bi_2O_3 is the correct formula for the bismuth ocher found in nature and called bismite). Attempts to isolate a sufficient quantity of the pearly scales from the gangue for separate analysis were not successful. According to a recent paper[1] by the writer the mineral bismite is probably $Bi(OH)_3$, as it seems very doubtful if Bi_2O_3 exists in nature as such.

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[1] Schaller, W. T., Bismuth ochers from San Diego County, Cal.: Jour. Am. Chem. Soc., vol. 33, 1911, p. 162.

AXINITE FROM CALIFORNIA.

LOCALITIES.

Well-crystallized axinite has been found at two widely separated points in California. In 1903–4 some large brownish crystals were found in Moosa Canyon, near Bonsall, San Diego County, by Mr. T. Freeman and forwarded by him to Dr. G. F. Kunz of New York, who determined them as axinite. The writer visited the locality in 1904 and collected a suite of the specimens which form the basis of this description. The work of collection was greatly facilitated through the kindness of Mr. Freeman and of Mr. J. J. Mack, both of San Diego County, whose assistance was of great value. A specimen of axinite from the Consumnes Copper Mine, Amador County, was lent to the writer from the collection of the University of California through the kindness of Prof. A. S. Eakle. The axinite, which is probably of contact origin, is associated with large epidote and small quartz crystals.

AXINITE FROM SAN DIEGO COUNTY.

OCCURRENCE.

The axinite of San Diego County appears in detached crystals associated with quartz, epidote, and a little laumontite in a much decomposed granite, and its true mode of occurrence is not determinable, for all the rock in the vicinity is greatly altered. The crystals range from minute size to a length of nearly 5 centimeters; they are generally flattened, rough, worn, and opaque, with small transparent areas scattered throughout the crystal mass. A few, which are highly decomposed, appear as a black mass consisting largely of manganese dioxide. The quartz on which the axinites are often grouped is found both in massive pieces and in distinct crystals. It is characteristically of the smoky variety, and often very closely resembles the axinite in color. A very few specimens consisted of radiated greenish epidote, surrounded by idiomorphic axinite into which the epidote fibers penetrate. The laumontite occurs sparingly as isolated white crystals situated on the other minerals.

CRYSTALLOGRAPHY.

The larger crystals of axinite are simple in their combinations and show the usual axinite forms, such as *m*, *M*, *r*, *z*, *c*, *s*, and *x*. The smaller crystals are more perfect and show a greater number of forms. Only a few of the crystals are at all suitable for measurement, most of them being too dull and uneven. Many, too, are considerably striated, and often a number are grouped in nearly parallel position.

The forms identified on these crystals are as follows, the position chosen being that of Miller as modified by Goldschmidt in his Winkeltabellen: $\{010\}$, $\{110\}$, $\{1\bar{1}0\}$, $\{1\bar{2}0\}$, $\{0\bar{3}1\}$?, $\{0\bar{1}1\}$, $\{0\bar{1}2\}$, $\{101\}$, $\{112\}$, $\{1\bar{2}1\}$, $\{1\bar{1}1\}$, $\{\bar{1}\bar{1}1\}$, $\{\bar{1}\bar{1}2\}$, $\{\bar{2}\bar{2}1\}$.

The following table gives the measurements of these forms as compared with the calculated values taken from Goldschmidt's Winkeltabellen and with the letters and symbols given by Dana for the same forms:

Forms and angles for axinite from San Diego County.

Goldschmidt's symbols.		Dana's symbols.		Measured.				Calculated.			
Letter.	Symbol.	Letter.	Symbol.	φ		ρ		φ		ρ	
				°	′	°	′	°	′	°	′
c	010	*M*	$1\bar{1}0$	0	00	90	00	0	00	90	00
w	110	*w*	$1\bar{3}0$	60	27	90	00	60	16	90	00
u	$1\bar{1}0$	*m*	110	135	22	90	00	135	24	90	00
l	$1\bar{2}0$	*a*	100	150	42	90	00	151	23	90	00
φ	$0\bar{3}1$	*φ*	$3\bar{3}1$	176	50	68	11	177	20	71	36
r	$0\bar{1}1$	*r*	$1\bar{1}1$	172	03	46	22	172	02	45	21
z	$0\bar{1}2$	*z*	$1\bar{1}2$	164	07	27	36	164	24	27	32
a	101	*y*	021	106	00	49	00	104	04	49	10
o	112	*o*	$\bar{1}32$	53	38	32	00	53	49	31	19
s	$1\bar{2}1$	*s*	201	153	31	68	29	153	49	68	32
x	$1\bar{1}1$	*x*	111	138	44	59	44	138	48	59	36
n	$\bar{1}\bar{1}1$	*n*	$1\bar{3}1$	117	17	57	43	117	16	57	38
δ	$\bar{1}\bar{1}2$	*δ*	$1\bar{3}2$	115	27	40	28	115	08	40	26

Of these forms $\{010\}$, $\{110\}$, $\{1\bar{1}0\}$, $\{1\bar{2}1\}$, and $\{0\bar{1}1\}$ are large, the other forms occur as small faces.

The form *κ* $\{\bar{2}\bar{2}1\}$ was noted on one crystal in a zone with the forms $\{110\}$ large, $\{\bar{2}\bar{2}1\}$ line face, $\{\bar{1}\bar{1}1\}$ medium, and $\{\bar{1}\bar{1}2\}$ line face.

CHEMICAL COMPOSITION.

A large sample was crushed and the clear fragments of axinite picked out. Treatment with heavy solution served to remove a little quartz similar in color and appearance which had been picked up with the axinite. The following is the average of several analyses. The water was given off above 110° and its amount was determined directly.

Analysis of axinite, San Diego County.

SiO_2	42.61
Al_2O_3	17.43
Fe_2O_3	.38
FeO	7.53
MnO	4.10
MgO	.44
CaO	19.74
H_2O	1.56
B_2O_3	6.04
	99.83

As this analysis was made before the oxidizing effect of grinding was known, the true amount of ferric oxide in the mineral may be even less than that given.

The ratios calculated from the analysis are shown herewith.

Ratios of analysis of axinite, San Diego County.

SiO_2	0.710=8.00
Al_2O_3 Fe_2O_3	.173=1.95
FeO MnO MgO	.174=1.96
CaO	.353=3.97
H_2O	.087= .98
B_2O_3	.086= .97

The above figures indicate the formula for axinite to be $8SiO_2.2Al_2O_3.2(Fe,Mn,Mg)O.4CaO.1H_2O.1B_2O_3$. If all the bivalent bases are grouped together, the formula reduces to $8SiO_2.2Al_2O_3.1B_2O_3.7RO$, the one proposed by Ford[1] for the mineral in a discussion of several analyses including his own, in the course of which paper he shows that the general formula for axinite may be written:

$$8SiO_2.\ B_2O_3.\ 2R_2'''O_3.\ 7R''O$$
$$R''' = Al, Fe'''$$
$$R'' = Ca, Fe'', Mn, Mg, H_2$$

Examination of the more recent trustworthy analyses of axinite has convinced the writer that the calcium content is constant, and that, as the iron and manganese vary reciprocally, there are two end products, one free from iron and the other free from manganese, and that all axinites may be considered as isomorphous mixtures of these two end products.

Thirteen trustworthy analyses, in nearly all of which the water was determined directly, were selected, and the ratios of the various constituents calculated. These analyses, arranged in the order of increasing amounts of manganese, are given below.

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[1] Ford, W. J., On the chemical composition of axinite: Am. Jour. Sci., 4th ser., vol. 15, 1903, p. 195.

Analyses of axinite.

No.	SiO_2.	B_2O_3.	Al_2O_3	Fe_2O_3	FeO.	MnO.	CaO.	MgO.	H_2O.	K_2O.	Na_2O.	(Cu, Zn, Pb)O.
1	42.89	6.02	18.25	0.64	7.11	1.06	19.89	2.23	2.14	0.11	0.36	....
2	43.46	5.61	16.33	2.80	6.78	2.62	20.19	1.73	1.45	.11	......	....
3	42.78	6.12	17.67	.99	6.02	2.99	20.16	2.41	1.40	......	......	....
4	41.53	4.62	17.90	3.90	4.02	3.79	21.66	.74	2.16	......	......	....
5	42.10	4.64	17.40	3.06	5.84	4.63	20.53	.66	1.80	......	......	....
6	42.40	4.71	17.39	.59	4.89	6.16	19.57	1.69	1.64	.25	.24	(F—.22)
7	42.40	4.88	17.26	1.33	4.27	6.97	19.53	1.30	1.90	......	......	....
8	42.55	4.20	16.37	3.79	4.06	7.69	19.28	1.02	(1.33)	......	......	....
9	41.96	4.61	17.69	.81	3.61	8.51	19.71	.97	1.93	......	......	(F—1.11)
10	42.85	5.17	16.96	5.00	......	9.59	18.49	.87	(75)	......	......	.19
11	41.80	5.61	17.15	1.11	2.84	10.71	19.51	.21	1.22	......	......	....
12	42.47	5.05	16.85	1.16	......	13.14	18.35	.26	1.21	......	......	1.73
13	42.77	5.10	16.73	1.03	......	13.69	18.25	.23	1.29	......	......	1.60

1. Jannasch and Locke, Zeitschr. anorg. Chemie, vol. 6, 1894, p. 57.
2. Rammelsberg, Zeitschr. Deutsch. geol. Gesell., vol. 21, 1869, p. 689.
3, 11. Ford, Am. Jour. Sci., 4th ser., vol. 15, 1903, p. 195.
4, 5. Whitfield, Am. Jour. Sci., 3d ser. vol. 34, 1887, p. 286.
6, 7, 9. Mauzelius, Geol. för. Förh.. vol. 17, 1895. p. 279.
8. Cleve, Geol. för. Förh., vol. 17, 1895 p. 279.
10, 12, 13. Genth, Am. Jour. Sci., 3d ser. vol. 41, 1891, p. 394.

In analyses 8 and 10 the water content was determined by ignition, and the ratios are for that reason omitted in the following table. The figures for the water content in analyses 12 and 13 are those obtained by Ford.[1] The percentage of fluorine (1.11) given in analysis 9 is undoubtedly too high.

Ratios from the foregoing analyses are shown in the following table. The small amounts of zinc, lead, copper, soda, and potash present have been added to the magnesia ratio.

Ratios of axinite analyses.

Analysis No.—	SiO_2.	B_2O_3.	Al_2O_3.	FeO.	MnO.	CaO.	MgO.	H_2O.
1	7.96	0.96	2.06	1.10	0.16	3.98	0.70	1.34
2	8.14	.90	2.00	1.06	.42	4.04	.50	.90
3	8.02	.98	1.98	.94	.48	4.04	.74	.86
4	7.82	.76	2.28	.64	.60	4.38	.20	1.36
5	7.92	.74	2.14	.92	.74	4.14	.18	1.14
6	7.84	.76	1.96	.76	.98	3.92	.54	1.16
7	7.84	.78	2.00	.66	1.10	3.90	.12	1.18
8	8.10	.70	2.12	.64	1.24	3.96	.32	....
9	7.88	.74	2.02	.56	1.36	4.00	.28	1.32
10	8.10	.84	2.26	None.	1.54	3.78	.26	....
11	7.84	.92	1.98	.44	1.72	3.98	.06	.76
12	8.06	.84	1.98	None.	2.12	3.76	.32	.78
13	8.38	.86	1.96	None.	2.28	3.84	.30	.84

The average of the above ratios of the 13 analyses given is $7.99SiO_2$. $0.83B_2O_3$. 2.06 $(Al,Fe)_2O_3$. 2.07 (Fe,Mn,Mg)O. 3.90CaO. $1.05H_2O$. The boric acid ratio is a little low because of the incomplete extraction of B_2O_3 in the analyses. The average ratios, like those of the analysis of axinite from Bonsall, San Diego County, are very close to the simple formula:

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[1] Loc. cit.

$$8SiO_2.2Al_2O_3.1B_2O_3.2(Fe,Mn,Mg)O.4CaO.1H_2O.$$

As can be seen by the table of analyses on page 40, the ferrous iron and manganese vary reciprocally, because of which fact the writer considers axinite an isomorphous mixture of the two minerals, ferroaxinite, $Al_2BHCa_2FeSi_4O_{16}$ and manganoaxinite, $Al_2BHCa_2MnSi_4O_{16}$. Whitfield[1] suggested that there were two such end products, but his formulas differed from those given above. These two compounds may be readily distinguished qualitatively, where either preponderates sufficiently in a mixture, by the color of the bead of the fused mineral. That of ferroaxinite is black, and that of manganoaxinite is very light colored or gray if a slight amount of iron is present.

One analysis, that by Baumert,[2] is purposely omitted, as the high calcium content (30.21 per cent) obtained occasions some doubt as to the accuracy of the analysis, especially as the sequioxides are also low.

The specific gravity of the mineral apparently increases with the amount of manganese present, as is shown in the following table, but it is probable that careful determinations on pure material will show that ferroaxinite is slightly the heavier.

Specific gravity of axinite.

Analysis No.—	Per cent MnO.	Specific gravity.
1	1.06	3.268
2	2.62	....
3	2.99	3.287
4	3.79	....
5	4.63	....
6	6.16	3.28
7	6.97	3.30
8	7.69	....
9	8.51	3.30
10	9.59	3.299
11	10.71	[a] 3.302
12	13.14	3.306
13	13.69	3.358

[a] Given by Ford (loc. cit.) as 3.028 by mistake. Ford has informed the writer that the value should be as given above.

It was proposed to investigate the various physical constants of axinite in order to see if corresponding variations could be determined for the different ratios of FeO to MnO, but the material available was lost by fire before the work could be undertaken.

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[1] Am. Jour. Sci., 3d ser., vol. 34, 1887, p. 286.

[2] Zeitsch. Nat. Halle, vol. 42, 1889, p. 1, and Dana's System of Mineralogy, 6th ed., p. 529.

AXINITE FROM AMADOR COUNTY.

CRYSTALLOGRAPHY.

The crystals of axinite from the Consumnes copper mine, Amador County, are very small, their dimensions rarely exceeding 2 millimeters, and are for the most part transparent and highly polished. They are associated with large epidote and quartz crystals, which are covered with a drusy coating of small axinites. These axinites lie on the epidote and quartz, and also penetrate them to some extent, some axinite being entirely embedded in the quartz. Preliminary measurements of two crystals showed that the small crystals were very rich in forms, and it was intended to continue the study of these crystals, as well as of the mineral axinite in general, at some future time. Of 24 forms noted on the crystals, 8 are apparently new. The list of forms follows, the symbols being given in Miller's orientation as modified by Goldschmidt in his Winkeltabellen. New forms are starred. $\{010\}$, $\{100\}$, $\{110\}$, *$\{210\}$, $\{120\}$, *$\{14.1.0\}$, $\{1\bar{1}0\}$, $\{3\bar{4}0\}$, $\{2\bar{3}0\}$, $\{3\bar{5}0\}$, $\{1\bar{3}0\}$, $\{9\bar{7}0\}$, *$\{9\bar{4}0\}$, *$\{7\bar{2}0\}$, *$\{9.\overline{10}.0\}$, *$\{2\bar{9}0\}$, $\{1\bar{2}0\}$, *$\{7\bar{8}0\}$, *$\{1.\overline{13}.0\}$, $\{112\}$, $\{011\}$, $\{0\bar{1}1\}$, $\{1\bar{2}1\}$, $\{1\bar{1}1\}$.

The average measurements of these forms as compared with the calculated values are shown in the table below.

Forms and angles, axinite.

[Asterisks indicate new form.]

Goldschmidt.		Dana.		Measured.				Calculated.			
Letter.	Symbol.	Letter.	Symbol.	ϕ		ρ		ϕ		ρ	
				°	′	°	′	°	′	°	′
c	010	*M*	$1\bar{1}0$	0	00	90	00	0	00	90	00
M	100	*b*	010	102	27	90	00	102	30	90	00
r	120	......	$1\bar{2}0$	36	15	90	00	36	15	90	00
w	110	*w*	$1\bar{3}0$	61	58	90	00	60	16	90	00
**A*	210	......	$1\bar{6}0$	80	22	90	00	80	06	90	00
**C*	14.1.0	......	1.29.0	99	23	90	00	99	22	90	00
**D*	$7\bar{2}0$	......	160	113	56	90	00	114	08	90	00
**E*	$9\bar{4}0$	......	270	119	45	90	00	119	51	90	00
S	$9\bar{7}0$	......	7.11.0	129	55	90	00	129	58	90	00
u	$1\bar{1}0$	*m*	110	135	24	90	00	135	24	90	00
**F*	$9.\overline{10}.0$	......	540	137	49	90	00	137	47	90	00
**G*	$7\bar{8}0$	......	430	138	22	90	00	138	26	90	00
α	$3\bar{4}0$	*α*	210	142	19	90	00	141	58	90	00
H	$2\bar{3}0$	*H*	310	144	07	90	00	144	40	90	00
β	$3\bar{5}0$	*β*	510	147	24	90	00	147	03	90	00
l	$1\bar{2}0$	*a*	100	151	21	90	00	151	23	90	00
h	$1\bar{3}0$	*h*	$3\bar{1}0$	159	18	90	00	158	58	90	00
**N*	$2\bar{9}0$	......	$9\bar{5}0$	165	18	90	00	165	12	90	00
**P*	$1.\overline{13}.0$	......	$13.\overline{15}.0$	174	34	90	00	174	26	90	00
e	011	*e*	$\bar{1}11$	6	36	45	42	7	58	45	16
x	$1\bar{1}1$	*x*	111	138	45	60	57	138	48	59	36
s	$1\bar{2}1$	*s*	201	153	00	69	05	153	49	68	32

Of the above forms, $\gamma\{120\}$ was first given by Sjögren[1] on axinite from Nordmarken.

The measurements of the narrow face gave the following values:

Measurements of $\gamma\{120\}$.

Symbol.	Measured.	Calculated.	Difference.
	° ′	° ′	° ′
$010 \wedge 120$	36 15	36 15	0 00
$110 \wedge 120$	24 12	24 01	0 11
$1\bar{1}0 \wedge 120$	98 55	99 09	0 14

The form $S\{9\bar{7}0\}$ was first noted by Franck[2] and was observed once as a narrow face giving a poor reflection.

Measurements of $S\ \{9\bar{7}0\}$.

Symbol.	Measured.	Calculated.	Difference.	Franck's measurement.
	° ′	° ′	° ′	° ′
$0\bar{1}0 \wedge 9\bar{7}0$	50 05	50 02	0 03	49 44
$1\bar{2}0 \wedge 9\bar{7}0$	21 27	21 25	0 02	....
$100 \wedge 9\bar{7}0$	27 07	27 28	0 21	....
$9.\overline{10}.0 \wedge 9\bar{7}0$	7 54	7 49	0 05	....

The following eight prisms are evidently new—at least they are not described in the literature of the subject, so far as known to the writer.

The form $A\{210\}$ occurs as a line face giving a poor reflection.

Measurements of $A\{210\}$.

Symbol.	Measured.	Calculated.	Difference.
	° ′	° ′	° ′
$100 \wedge 210$	22 08	22 24	0 16
$14.1.0 \wedge 210$	19 01	19 16	0 15

The prism $C\{14.1.0\}$ has more of a vicinal symbol than most of the new prisms, but the measured and calculated angles agree so well that the form is considered established. It occurs as a line face giving a poor reflection.

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[1] Sjögren, Hj., Beiträge z. Mineralogie Schwedens: Bull. Geol. Inst. Upsala, vol. 1, 1892, p. 1.

[2] Franck, A., Bull. Acad. Belgique, vol. 25, 1893, p. 17.

Measurements of $C\{14.1.0\}$.

Symbol.	Measured.		Calculated.		Difference.	
	°	′	°	′	°	′
$1\bar{1}0\wedge 14.1.0$	36	01	36	02	0	01
$100\wedge 14.1.0$	3	07	3	08	0	01

The new form $D\{7\bar{2}0\}$ is present once as a line face giving a poor reflection.

Measurements of $D\{7\bar{2}0\}$.

Symbol.	Measured.		Calculated.		Difference.	
	°	′	°	′	°	′
$0\bar{1}0\wedge 7\bar{2}0$	66	04	65	52	0	12
$100\wedge 7\bar{2}0$	11	08	11	38	0	30
$9\bar{4}0\wedge 7\bar{2}0$	5	49	5	43	0	06

The prism $E\{9\bar{4}0\}$ occurs with the preceding form, and, like it, is a line face giving a poor reflection.

Measurements of $E\{9\bar{4}0\}$.

Symbol.	Measured.		Calculated.		Difference.	
	°	′	°	′	°	′
$0\bar{1}0\wedge 9\bar{4}0$	60	15	60	09	0	06
$100\wedge 9\bar{4}0$	16	57	17	21	0	24
$9.\overline{10}.0\wedge 9\bar{4}0$	18	04	17	56	0	08

The form $F\{9.\overline{10}.0\}$ approaches to a vicinal form, though the measured and calculated angles agree well. It is present as a narrow face much broader than a line face and gives a fairly good reflection. Apparently, it replaces the form $u\{1\bar{1}0\}$, for the two are not found together.

Measurements of $F\{9.\overline{10}.0\}$.

Symbol.	Measured.		Calculated.		Difference.	
	°	′	°	′	°	′
$0\bar{1}0\wedge 9.\overline{10}.0$	42	11	42	13	0	02
$1\bar{2}0\wedge 9.\overline{10}.0$	13	33	13	36	0	03
$100\wedge 9.\overline{10}.0$	35	01	35	17	0	16

The new prism $G\{7\bar{8}0\}$ is very close to the above, though the measured and calculated angles agree well. It is probably identical with or near to the form $\{15.\overline{17}.0\}$, described by Offret and Gonnard.[1] It is present as a line face with $u\{1\bar{1}0\}$ on the crystal from Amador County. The reflection was fairly good.

Measurements of $G\{7\bar{8}0\}$.

Symbol.	Measured.	Calculated.	Difference.	Measured by Offret and Gonnard.
	° ′	° ′	° ′	° ′
$0\bar{1}0 \wedge 7\bar{8}0$......	41 38	41 34	0 04	....
$1\bar{1}0 \wedge 7\bar{8}0$......	2 58	3 02	0 04	2 48
$1\bar{2}0 \wedge 7\bar{8}0$......	12 39	12 57	0 18	....

The form $N\{2\bar{9}0\}$ occurs as a narrow face giving a fairly good reflection.

Measurements of $N\{2\bar{9}0\}$.

Symbol.	Measured.	Calculated.	Difference.
	° ′	° ′	° ′
$0\bar{1}0 \wedge 2\bar{9}0$......	14 42	14 48	0 06
$1\bar{2}0 \wedge 2\bar{9}0$......	13 45	13 49	0 04
$1\bar{1}0 \wedge 2\bar{9}0$......	29 54	29 48	0 06

The new prism $P\{1.\overline{13}.0\}$ is of a vicinal character, but, like some of the other forms here described, the measured and calculated angles agree well. It is present as a narrow face next to $\{0\bar{1}0\}$, and gives a good reflection.

Measurements of $P\{1.\overline{13}.0\}$.

Symbol.	Measured.	Calculated.	Difference.
	° ′	° ′	° ′
$0\bar{1}0 \wedge 1.\overline{13}.0$...	5 26	5 34	0 08
$1\bar{2}0 \wedge 1.\overline{13}.0$...	23 11	23 25	0 14
$1\bar{1}0 \wedge 1.\overline{13}.0$...	39 10	39 02	0 08

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[1] Offret, A., and Gonnard, F., Note cristallographique sur l'axinite de l'Oisans: Bull. Soc. franç. minéral., vol. 16, 1893, p. 75.

CHEMICAL COMPOSITION.

Lack of material made it impossible to obtain enough axinite for a more complete analysis than is here given. The sample analyzed was not quite pure, for small amounts of impurities were plainly visible before the sample was ground. It was necessary to determine the boric acid content by difference. The analysis and ratios follow:

Analysis and ratios of axinite from Amador County.

	Analysis.	Ratios.
SiO_2	42.79	8.00
Al_2O_3	16.38	1.81
FeO	4.22	2.05
MnO	8.76	
MgO	0.09	
CaO	19.21	3.85
H_2O	1.85	1.16
B_2O_3 (by difference)	6.70	1.02
	100.00	

The ratios approximate those proposed in the first part of this paper, but the material was of too poor quality and of too slight amount to admit of accurate deductions from the analysis. It may be noted that in the Amador County axinite the manganese predominates over the iron, whereas in the axinite from San Diego County the reverse is true.

In a recent number of Tschermak's Mineralogische und Petrographische Mitteilungen Fromme[1] gives, in connection with a description of several minerals from the Radautale, an analysis of axinite. The formula derived from that analysis and Fromme's discussion of the composition of axinite require some comment. The analysis given is as follows:

Analysis of axinite from Radautale (by Fromme).

SiO_2	41.73
B_2O_3	6.30
Al_2O_3	17.08
Fe_2O_3	1.87
FeO	1.35
CaO	18.65
MnO	11.54
MgO	0.34
H_2O	1.81
	100.67

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[1] Fromme, J., Chemisch-mineralogische Notizen aus dem Radautale: Min. pet. Mitt., vol. 28, 1909, pp. 305–328.

Fromme rightly combines the ferric iron with the alumina, and also places the manganese and magnesia together in deducing the formula from the analysis. His view that the ferrous iron and calcium replace each other is, however, open to serious question, for in general FeO and CaO do not isomorphously replace each other in silicates, as is shown, for example, by the behavior of these compounds in hedenbergite and ilvaite. The fact that FeO and CaO are not isomorphous in axinite is made clear by the table of analyses given on p. 40. The proportion of $CaO+FeO$ to SiO_2, for instance, is variable, and depends on the amount of FeO present, for both the SiO_2 and CaO are fairly constant.

Curiously enough, Fromme deduces from his analysis the formula of a *magnesium* axinite, which he regards as the primary type or "Grundtypus," even though his analysis shows only 0.34 per cent MgO and despite the fact that an analysis of axinite in which MgO predominates has never been published. Fromme calls his axinite a relatively pure manganese axinite, even though in the same sentence he speaks of the magnesium axinite as the type.

The formula proposed by Fromme for manganese axinite, namely, $HMnCa_2BAl_2Si_4O_{16}$, is identical with that advanced by the writer; the isomorphous relation of the $FeO+MnO+MgO$ seems, however, to have escaped Fromme's notice. The general formula $HR''R_2''BAl_2Si_4O_{16}$ was long ago proposed by Rammelsberg, though Ford grouped the bivalent bases together rather than consider them present in fixed amount. It is the writer's belief that the evidence shows that the CaO is beyond question definite in amount and that the H_2O and the $FeO+MnO+MgO$ are probably in definite proportion. Among the many other writers who have accepted calcium as constant is Tschermak, who, however, writes the formula for axinite $HMgCa_2BAl_2Si_4O_{16}$ with admixture of the related iron and manganese oxides. Whitfield proposed the isomorphous relation of the FeO and the MnO, but otherwise his formulas do not accord with more recent data. Therefore the view here proposed that axinite consists essentially of the two minerals, ferroaxinite ($HFeCa_2BAl_2Si_4O_{16}$) and manganoaxinite ($HMnCa_2BAl_2Si_4O_{16}$) although by no means new, puts forward clearly the evidence as it rests to-day. The existence of the corresponding magnesium axinite in a pure state is strongly indicated, but has not yet been demonstrated, for the ratio of MgO is, in all the analyses available, much less than that of $FeO+MnO$.

ALBITE FROM LAWSONITE SCHIST, MARIN COUNTY, CALIFORNIA.

ASSOCIATION.

Among the minerals found in the lawsonite schist at Reed Station, Marin County, Cal., albite is represented in a number of specimens by well-developed crystals, some of which are nearly a centimeter across. The albite seems to be concentrated at one point where the ground is strewn with small cavernous specimens, consisting chiefly of glaucophane and albite. Lawsonite has not been found directly associated with albite, the only mineral occurring with the albite being glaucophane.

The results herewith presented were attained some eight years ago, but they have been withheld, as it was planned to present a more complete paper on all the minerals mentioned herein. As almost all those collected by the writer were lost in the fire in the Survey Building, in December, 1908, the plan had to be abandoned and the data obtained for the albite are now presented. A brief note on lawsonite was published some years ago by the writer in conjunction with Dr. W. F. Hillebrand.[1]

The other minerals found in the schist with lawsonite are, as enumerated by Ransome,[2] glaucophane, actinolite, muscovite (first erroneously described as margarite), epidote, garnet, rutile, titanite, chlorite (pseudomorph after garnet), zoisite, pyrite. Besides these, there were found albite, abundant and in good crystals, chlorite in large sheets (several centimeters across) of a dark-green color, limonite pseudomorph after pyrite, anthophyllite (?), and talc.

FORMS AND ANGLES.

A number of new forms were found on these albite crystals when they were measured, but the forms have all since been described by other writers. A very important paper on the crystallography of albite has recently appeared[3] to which frequent reference will be made.

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[1] Schaller, W. T., and Hillebrand, W. F., Crystallographical and chemical notes on lawsonite: Am. Jour. Sci., 4th ser., vol. 17, 1904, p. 195; and Bull. U. S. Geol. Survey No. 262, 1905, p. 58.

[2] Bull. Dept. Geology Univ. California, vol. 1, 1896, p. 301.

[3] Dreyer, C., and Goldschmidt, V., Ueber Albit von Grönland: Meddelelser om Grønland, vol. 34, 1907, separate, 60 pp., 5 plates, 2 figs.

The forms determined by measurements on the albite crystals are as follows:

Forms on albite.

$c\ \{001\}$
$b\ \{010\}$
$e\ \{021\}$
$n\ \{0\bar{2}1\}$
$x\ \{\bar{1}01\}$
$y\ \{\bar{2}01\}$
$\zeta\ \{150\}$
$f\ \{130\}$
$Z\ \{120\}$
$K\ \{350\}$
$m\ \{110\}$
$M\ \{1\bar{1}0\}$
$z\ \{1\bar{3}0\}$
$\gamma\ \{\bar{1}12\}$
$p\ \{\bar{1}11\}$
$g\ \{\bar{2}21\}$
$\delta\ \{\bar{1}\bar{1}2\}$
$o\ \{\bar{1}\bar{1}1\}$
$u\ \{\bar{2}\bar{2}1\}$
$X\ \{\bar{2}\bar{4}1\}$
$\eta\ \{\bar{1}\bar{3}1\}$
$\omega\ \{\bar{3}12\}$
$a\ \{100\}$

The measurements, on which the more common forms were identified, are given below:[1]

Forms and angles, albite.

Symbol.	Measured.		Calculated.	
	°	′	°	′
$c \wedge b = (001) : (010)$	93	36	93	31(M).
$c \wedge e = (001) : (021)$..........	43	49	43	10(D).
$c \wedge c = (001) : (00\bar{1})$........	7	08	7	02(M).
$c \wedge m = (001) : (110)$........	65	12	65	12(M).
$c \wedge M = (001) : (1\bar{1}0)$........	69	02	69	05(M).
$c \wedge y = (001) : (\bar{2}01)$........	98	03	97	52(M).
$x \wedge y = (\bar{1}01) : (\bar{2}01)$........	29	59	29	57(M).
$b \wedge f = (010) : (130)$........	30	23	30	24(G).
$c \wedge p = (001) : (\bar{1}11)$........	56	10	55	53(D).
$c \wedge o = (001) : (\bar{1}\bar{1}1)$........	57	38	57	41(M).
$c \wedge \delta = (001) : (\bar{1}\bar{1}2)$........	30	05	30	04(M).
$o \wedge x = (\bar{1}\bar{1}1) : (\bar{1}01)$........	27	22	27	26(M).
$b \wedge p = (010) : (\bar{1}11)$........	60	14	60	16(M).
$b \wedge X = (010) : (\bar{2}\bar{4}1)$........	39	40	39	24(D).
$b \wedge u = (0\bar{1}0) : (\bar{2}\bar{2}1)$........	59	42	59	32(D).
$\eta \wedge X = (\bar{1}\bar{3}1) : (\bar{2}\bar{4}1)$........	18	25	18	55(D).
$b \wedge f = (010) : (130)$........	30	25	30	24(G).
$b \wedge Z = (010) : (120)$........	40	34	41	25(G).

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[1] The letter following the value of the calculated angles refers to the source of the angle, as it was not deemed necessary to recalculate all the angles used: M = Melczer, G., Zeitschr. Kryst. Min., vol. 40, 1905, p. 571; D = Dana, E. S., System of mineralogy, 6th ed., 1892, p. 328; G = Dreyer, C., and Goldschmidt, V., loc. cit.

The crystals showing the rarer forms were remeasured on the two-circle goniometer, the most important of the values obtained being shown below.

Measurement of rare forms, albite.

Letter.	Symbol.	Measured.		Calculated.	
		ϕ	ρ	ϕ	ρ
		° ′	° ′	° ′	° ′
ζ	150	19 19	90 00	19 21	90 00
K	350	46 29	90 00	46 40	90 00
n	$0\bar{2}1$	154 04	49 28	154 30	49 21
g	$\bar{2}21$	49 13	62 20	50 29	62 12
ω	$\bar{3}12$	70 07	46 12	69 32	46 04
X	$\bar{2}\bar{4}1$	146 16	68 45	145 50	69 01
η	$\bar{1}\bar{3}1$	164 00	59 08	163 17	59 08
u	$\bar{2}\bar{2}1$	125 32	60 05	125 16	60 51
a	100	87 26	90 00	90 28	90 00

There was also present on crystal No. 2 a very narrow face in the prism zone giving a distinct but faint signal. Its position could not be definitely determined, but its symbol is near to {490}, though the measurements agree closer with the more complex {5.11.0}. The form must, therefore, be referred to the already large class of doubtful forms. The angle values are shown below.

Measurements of doubtful prism.

	Measured.	Calculated for {5.11.0}	Calculated for {490}.
	° ′	° ′	° ′
130 $\wedge$?............	8 19	8 19	7 41
150 $\wedge$?............	19 07	19 22	18 44
350 $\wedge$?............	8 03	7 57	8 35
110 $\wedge$?............	21 57	21 55	22 33
010 $\wedge$?............	38 26	38 43	38 05

DESCRIPTION OF RARER FORMS.

e{021} was noticed but once as a line face, and the form is very rare on these crystals, the corresponding dome *n*{$0\bar{2}1$} being observed fairly often.

ζ{150} was found only once as a line face, on crystal No. 2, with *bfkmMz*. The form was only recently definitely determined by Dreyer and Goldschmidt.

$Z\{120\}$, a rare form, but well confirmed by Dreyer and Goldschmidt, was found once as a narrow face on crystal No. 14.

$K\{350\}$, determined as a new form when measured, was found by Dreyer and Goldschmidt, who report its occurrence on five crystals with 8 faces. By the writer it was observed on four crystals. The records of the measurements of the form on crystals Nos. 12 and 15 are lost, but for Nos. 2 and 8 they are as follows:

Measurements of $K\{350\}$, *albite.*

Symbol.	Measured.		Calculated.	
	°	′	°	′
Crystal No. 2:				
$\zeta \wedge K = (150):(350)$.....	27	30	27	19
$f \wedge K = (130):(350)$.....	16	18	16	16
$m \wedge K = (110):(350)$.....	13	34	13	58
Crystal No. 8:				
$b \wedge K = (010):(350)$.....	47	29	46	40
$f \wedge K = (130):(350)$.....	17	04	16	16
$m \wedge K = (110):(350)$.....	11	39	13	58

$g\{\bar{2}\bar{2}1\}$ and $u\{\bar{2}\bar{2}1\}$ are rare forms, noted several times on these crystals, though never were both forms seen on the same crystal.

$X\{\bar{2}\bar{4}1\}$, also new when first observed, was described at the same time as new by Bowman[1] and was found once by Dreyer and Goldschmidt. The form was noticed on two crystals by the writer, in both cases with $\eta\{\bar{1}\bar{3}1\}$.

$\eta\{\bar{1}\bar{3}1\}$, first determined by Viola (1895) and fully confirmed by the measurement of 23 faces by Dreyer and Goldschmidt, was noticed twice by the writer each time with $X\{\bar{2}\bar{4}1\}$.

$\omega\{\bar{3}12\}$, was measured as a small face with poor development on crystal No. 2. The form was first found by Dreyer and Goldschmidt and as the measured and calculated angles found by the writer agree well, no hesitancy is felt in referring the face measured to this form.

A very narrow face gave a poor reflection whose measurement approximated to the value for $a\{100\}$, a determined form.

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[1] Mineralog. Mag., vol. 13, 1902, p. 115.

COMBINATIONS.

The combinations observed on these albite crystals are given below.

Combinations on albite crystals.

Crystal No.—	c	b	e	n	x	y	ζ	f	Z	K	m	M	z	γ	p	g	δ	o	u	X	η	ω
1	c	b	....	....	x	y	....	f	....	....	m	M	z	....	p	....	....	o	u	....	....	....
2	c	b	....	....	x	y	ζ	f	....	K	m	M	z	....	....	....	δ	o	u	X	η	ω
3	c	b	e	n	x	y	....	f	....	....	m	M	z	γ	p	g	δ	o	....	....	....	....
4	c	b	....	....	x	y	....	f	....	....	m	M	z	....	p	....	....	o	....	....	....	....
5	c	b	....	....	....	y	....	....	....	....	m	M	z	....	p	....	....	....	....	....	....	....
6	c	b	....	....	x	y	....	....	....	....	m	....	z	....	p	....	....	....	....	....	....	....
7	c	b	....	....	x	y	....	....	....	....	....	M	z	....	p	....	....	....	....	....	....	....
8	c	b	....	....	x	y	....	f	....	K	m	....	....	....	....	....	δ	o	....	X	η	....
9	c	b	....	....	x	y	....	f	....	....	....	M	z	γ	p	....	....	....	....	....	....	....
10	c	b	....	....	x	y	....	....	....	....	....	M	z	....	p	....	δ	o	....	....	....	....
11	c	b	....	n	x	y	....	....	....	....	....	M	z	γ	p	....	....	o	....	....	....	....
12	c	b	....	....	....	....	....	f	....	K	m	M	z	....	p	....	....	o	....	....	....	....
13	c	b	....	n	x	y	....	f	....	....	....	M	z	γ	p	g	....	....	....	....	....	....
14	c	b	....	n	x	y	....	f	Z	....	m	M	z	....	....	....	δ	o	....	....	....	....
15	c	b	....	....	x	y	....	f	....	K	....	M	z	γ	p	....	....	....	....	....	....	....
16	c	b	....	n	x	y	....	f	....	....	....	M	z	....	....	....	δ	o	....	....	....	....
17	c	b	....	....	x	y	....	f	....	....	m	M	z	....	p	g	....	....	....	....	....	....
18	c	b	....	n	x	y	....	....	....	....	....	M	z	γ	p	....	δ	o	....	....	....	....
19	c	b	....	....	x	y	....	....	....	....	m	M	z	....	p	....	....	....	....	....	....	....
20	c	b	....	....	x	y	....	....	....	....	....	M	z	....	....	....	....	o	....	....	....	....

From the table of combinations, it can readily be seen that the common forms are: *c*, *b*, *x*, *y*, *f*, *m*, *M*, *z*, *p*, *o*, while the less common forms, or those that were noted on more than two crystals and yet on less than half of those measured are: *n*, *γ*, *g*, *δ*, *K*, which leaves, as the forms of the third or rare class: *e*, *ζ*, *Z*, *u*, *X*, *η*, *ω*.

HABIT.

In habit the crystals are usually short prismatic or nearly equidimensional, rarely somewhat elongated prismatic or slightly tabular, parallel to $b\{010\}$. Though one simple crystal (No. 1) was observed, all the others are twinned on the albite law. Usually there are but two individuals, though in a number of cases several twinning lamellæ run through the center of the crystal and sometimes give bright lamellæ, in the zone *bx*, which faces were at first thought to be new forms, but as shown by Dreyer and Goldschmidt[1] for the forms $\{\bar{7}97\}$ and $\{7\bar{5}7\}$ of Melczer,[2] are probably induced by twinning lamellæ. Thus there was measured, in the zone *bx*, for the face *l*: $b \wedge l = 66° \ 10'$, $67° \ 14'$; $x \wedge l = 26° \ 05'$, $27° \ 03'$; $p \wedge l = 6° \ 19'$, $7° \ 02'$; but $b \wedge p = 60° \ 16'$ and $p \wedge o' = 6° \ 32'$; therefore $b \wedge o' = 66° \ 48'$. Further, since $x \wedge o' = 27° \ 32'$ and $p \wedge o' = 6° \ 32'$, the face *l*, the measurements of which correspond to the angle values just given, is doubtless *o* in twin position.

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[1] Dreyer, C., and Goldschmidt, V., Ueber Albit von Grönland: Meddelelser om Grønland, vol. 34, 1907, separate, p. 11.

[2] Zeitschr. Kryst. Min., vol. 40, 1905, p. 583.

NOTES ON CRYSTALLOGRAPHY OF PHENACITE.

PHENACITE FROM NEW HAMPSHIRE.

Some crystals of phenacite from Bald Face Mountain, Chatham, N. H., were received for investigation through Prof. F. W. Clarke. The loose crystals resemble very much those described by Farrington[1] from the same locality, but the ones at the writer's disposal were somewhat richer in forms, a total of 12 having been noted. Of the forms given in the table below, *a* $\{11\bar{2}0\}$, *m* $\{10\bar{1}0\}$, *r* $\{10\bar{1}1\}$, *d* $\{01\bar{1}2\}$, *p* $\{11\bar{2}3\}$, *s* $\{21\bar{3}1\}$, and s_1 $\{3\bar{1}\bar{2}1\}$ were observed by Farrington.

Forms and angles on phenacite from Chatham, N. H.

Letter.	Symbol.	Measured.		Calculated.		Size of face.
		φ	ρ	φ	ρ	
		° ′	° ′	° ′	° ′	
a	$11\bar{2}0$	30 00	90 00	30 00	90 00	Medium.
m	$10\bar{1}0$	0 00	90 00	0 00	90 00	Medium.
r	$10\bar{1}1$	0 03	37 24	0 00	87 21	Large.
d	$01\bar{1}2$	0 12	21 20	0 00	20 53	Medium.
z	$01\bar{1}1$(?)	0 02	40 42	0 00	37 21	Line face.
μ	$02\bar{2}1$	0 00	56 46	0 00	56 46	Line face.
δ	$14\bar{5}6$	11 13	30 11	10 53	30 14	Minute.
v	$21\bar{3}4$	19 05	27 11	19 06	26 47	Line face.
x	$12\bar{3}2$	19 01	45 04	19 06	45 17	Minute.
s	$21\bar{3}1$	19 04	64 03	19 06	63 39	Line face.
s_1	$3\bar{1}\bar{2}1$	19 19	63 30	19 06	63 39	Line face.
p	$11\bar{2}3$	30 10	24 01	30 00	23 47	Small.
p_1	$2\bar{1}\bar{1}3$	30 18	23 59	30 00	23 47	Small.
o	$4\bar{2}\bar{2}3$	30 01	41 29	30 00	41 23	Minute.

FORM SYSTEM OF PHENACITE.

The forms for phenacite are given in the orientation chosen by Dana in preference to that of Goldschmidt, in which the symbols are more complex than in the former. A review of the literature of phenacite since the publication of Goldschmidt's Winkeltabellen has shown that a number of new forms are to be added to the list given by him, in order to have a complete form system for the mineral. The following table of forms has therefore been compiled and gives all the forms found in the literature for phenacite (doubtful and vicinal forms not included), and is perhaps the most practicable table for the identification of forms when the mineral is measured by the two-circle method. If no reference for a form is given in the last column of the table, it signifies that the form has been recognized by at least three independent observers and therefore is well substantiated. Otherwise references to the source of the description of the form are given.

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[1] Farrington, O. C., Notes on various minerals in the museum collection: Field Columbian Museum Publications, Geol. ser., vol. 3, 1908, p. 157.

Forms and angles for phenacite.

No.	Letter.	Symbol.			ϕ	ρ	References.
		Goldschmidt.	Miller.	Bravais.			
					° ′	° ′	
1	*m*	$\infty 0$	$2\bar{1}\bar{1}$	$10\bar{1}0$	0 00	90 00	....
2	*a*	∞	$10\bar{1}$	$11\bar{2}0$	30 00	90 00	....
3	*k*	4∞	$3\bar{1}\bar{2}$	$41\bar{5}0$	10 53	90 00	....
4	d_1	$+\frac{1}{2}0$	411	$10\bar{1}2$	0 00	20 53	8
5	*d*	$-\frac{1}{2}0$	110	$01\bar{1}2$	0 00	20 53	....
6	*r*	$+10$	100	$10\bar{1}1$	0 00	37 21	....
7	*z*	-01	$22\bar{1}$	$01\bar{1}1$	0 00	37 21	....
8	μ	-02	$11\bar{1}$	$02\bar{2}1$	0 00	56 46	....
9	δ	$-\frac{1}{6}\,\frac{2}{3}$	$43\bar{1}$	$14\bar{5}6$	10 53	30 14	4, 9
10	*t*	$-\frac{1}{4}\,\frac{3}{4}$	$32\bar{1}$	$13\bar{4}4$	13 54	34 32	4
11	λ	$+\frac{3}{2}\,\frac{1}{2}$	$30\bar{1}$	$31\bar{4}2$	13 54	54 00	....
12	ξ	-13	212	$13\bar{4}1$	13 54	70 02	1, 5
13	*v*	$+\frac{1}{2}\,\frac{1}{4}$	310	$21\bar{3}4$	19 06	26 47	2, 3
14	*x*	$-\frac{1}{2}\,1$	$21\bar{2}$	$12\bar{3}2$	19 06	45 17	....
15	*s*	$+21$	$20\bar{1}$	$21\bar{3}1$	19 06	63 39	....
16	*b*	$+\frac{3}{4}\,\frac{1}{2}$	$41\bar{1}$	$32\bar{5}4$	23 25	39 45	7
17	b_1	$-\frac{1}{2}\,\frac{3}{4}$	$11.5.\bar{4}$	$23\bar{5}4$	23 25	39 45	7
18	ω	$-1\frac{3}{2}$	$31\bar{2}$	$23\bar{5}2$	23 25	58 59	....
19	ς	$+32$	$30\bar{2}$	$32\bar{5}1$	23 25	73 16	....
20	*e*	$+\frac{4}{7}\,\frac{3}{7}$	$62\bar{1}$	$43\bar{7}7$	25 17	33 33	7
21[a]	y_1	$-\frac{1}{5}1$	$4\bar{2}3$	$15\bar{6}5$	8 57	40 22	6
22	*p*	$+\frac{1}{3}\frac{1}{3}$	210	$11\bar{2}3r$	30 00	23 47	....
23	p_1	$-\frac{1}{3}\frac{1}{3}$	201	$2\bar{1}\bar{1}3l$	30 00	23 47	....
24	o_1	$+\frac{2}{3}\frac{2}{3}$	$31\bar{1}$	$22\bar{4}3r$	30 00	41 23	8
25	*o*	$-\frac{2}{3}\frac{2}{3}$	$3\bar{1}1$	$4\bar{2}\bar{2}3l$	30 00	41 23	....

[a] The form *y* $\{15\bar{6}5\}$ should follow No. 8.

1. Beyrich, Pogg. Ann., vol. 34, 1835, p. 519; vol. 41, 1837, p. 323 (Goldschmidt, Index der Krystallformen der Mineralien, vol. 2, 1890, p. 464).
2. Rose, Pogg. Ann., vol. 69, 1846, p. 145 (Hintze, Handbuch, vol. 2, p. 41).
3. Seligmann, Neues Jahrb. Min., Geol. u. Pal., vol. 1, 1880, p. 129.
4. Descloizeau, Bull. Soc. franç. minéral., vol. 9, 1886, p. 171.
5. Lacroix, Minéralogie de la France, vol. 1, 1893–1895, p. 205.
6. Spencer, Mineralog. Mag., vol. 14, 1906, p. 178.
7. Zimányi, Ann. Musei Hungarici, vol. 7, pt. 1, 1909, p. 347.
8. Slavík, Bull. intern. Acad. Bohème, 1909, vol. 14, p. 1.
9. The present paper.

NOTES ON NEPTUNITE.

NEPTUNITE FROM CALIFORNIA.

A large suite of specimens of benitoite and neptunite were collected by Dr. Ralph Arnold [1] and turned over to the writer for investigation. As Dr. Louderback was then intending to publish a full description of these minerals, the investigation was postponed. A single crystal was measured and a partial analysis was made in order to classify the so-called carlosite.[2] Since then the crystallography,[3] the chemical composition,[4] and the occurrence [5] of the mineral have been described.

The single crystal measured is prismatic and of the habit described by Ford. The forms present are $c\{001\}$, $a\{100\}$, $m\{110\}$, $s\{111\}$, $o\{\bar{1}11\}$, $i\{\bar{1}12\}$, $g\{\bar{2}11\}$, $p\{\bar{3}11\}$, and $*h\{887\}$. The measurements of these forms gave the following values:

Forms and angles for neptunite.

Letter.	Symbol.	Measured.		Calculated.	
		ϕ	ρ	ϕ	ρ
		° ′	° ′	° ′	° ′
c	001	90 06	25 23	90 00	25 38
a	100	90 00	90 00	90 00	90 00
m	110	40 21	90 00	40 07	90 00
s	111	55 07	54 16	55 10	54 43
o	$\bar{1}11$	14 26	40 08	13 57	39 45
i	$\bar{1}12$	18 52	22 56	19 05	23 08
g	$\bar{2}11$	48 11	51 00	47 29	50 05
p	$\bar{3}11$	62 52	60 12	62 39	60 22

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[1] Arnold, R., Notes on the occurrence of the recently described gem mineral benitoite: Science, vol. 27, 1908, p. 312.

[2] Louderback, G. D., and Blasdale, W. C., Benitoite, a new California gem mineral: Bull. Dept. Geology. Univ. California, vol. 5, 1907, p. 149.

[3] Ford, W. E., Neptunite crystals from San Benito County, Cal.: Am. Jour. Sci., 4th ser., vol. 27, 1909, p. 235.

[4] Bradley, W. M., On the analysis of the mineral neptunite from San Benito County, Cal.: Am. Jour. Sci., 4th ser., vol. 28, 1909, p. 15.

[5] Louderback, G. D., and Blasdale, W. C., Benitoite, its paragenesis and mode of occurrence: Bull Dept. Geology Univ. California, vol. 5, 1909, p. 331.

In addition to these forms, a large face near to *s* {111} is present on one side of the crystal. Its measurement corresponds to the symbol **h*{887}, and as the form occurs as a large plane face, it is considered as well established. The face $(8\bar{8}7)$ is much larger than $(1\bar{1}1)$ and a little smaller than (111) and is one of the largest faces on the crystal. The corresponding face (887) is not present. The measurements are as follows:

Measurements of new form h {887}.

Measured.	Calculated.
$\phi=53° 41'$	$\phi=53° 43'$
$\rho=57° 31'$	$\rho=57° 20'$

A very narrow face vicinal to $(\bar{1}\bar{1}2)$ was also observed. The form *g* $\{\bar{2}11\}$, described as new by Ford, is present on this crystal as two large dull uneven faces. The form is probably characteristic of this locality, as it was seen on a number of other crystals.

FORM SYSTEM OF NEPTUNITE.

As the number of forms for neptunite has considerably increased since the original description of the mineral in 1893, a compilation of all the described forms with the coordinate angles thereto is given below. As in a similar table appearing in this paper a reference to the description on which the form is based is given, unless the form has been three times independently described. The values ϕ and ρ for the forms not given in Goldschmidt's Winkeltabellen have, except for *h*{887}, been taken from the table furnished by Hlawatsch.[1]

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[1] Hlawatsch, C., Bemerkungen zum Aragonit von Rohitsch, Natrolith und Neptunit von San Benito: Min. pet. Mitt., vol. 28, 1909, p. 293.

Forms and angles of neptunite.

Monoclinic, $a = 1.3164$; $c = 0.8076$; $\beta = 64°22'$.

No.	Letter.	Symbol.		ϕ		ρ		References.
		Miller.	Goldschmidt.					
				°	′	°	′	
1	*b*	010	0∞	0	00	90	00	....
2	*m*	110	∞	40	07	90	00	....
3	*a*	100	$\infty 0$	90	00	90	00	....
4	*o*	$\bar{1}11$	-1	13	57	39	45	....
5	*i*	$\bar{1}12$	$-\frac{1}{2}$	19	05	23	08	....
6	*r*	$\bar{2}21$	-2	22	12	60	11	2, 4
7	*g*	$\bar{2}11$	-21	47	29	50	05	....
8	*v*	221	$+2$	48	44	67	47	1, 2
9	*h*	887	$+\frac{8}{7}$	53	43	57	20	5
10	*s*	111	$+1$	55	10	54	43	....
11	*γ*	$\bar{5}22$	$-\frac{5}{2}1$	56	31	55	40	3
12	*p*	$\bar{3}11$	-31	62	39	60	22	....
13	*u*	$\bar{5}12$	$-\frac{5}{2}\frac{1}{2}$	71	42	52	08	....
14	*x*	311	$+31$	72	14	69	18	2
15	*q*	$\bar{7}12$	$-\frac{7}{2}\frac{1}{2}$	78	04	62	47	2
16	*f*	$\bar{1}01$	-10	90	00	11	20	2
17	*c*	001	0	90	00	25	38	....
18	*e*	$\bar{2}01$	-20	90	00	41	22	....
19	*d*	$\bar{3}01$	-30	90	00	57	21	1, 2

1. Flink, G., Beschreibung eines neuen Mineralfundes aus Grönland: Zeitschr. Kryst. Min., vol. 23, 1894, p. 346.
2. Flink, G., Böggild, O. B., and Winter, C., Untersuchungen über Mineralien von Julianehaab: Meddelelser om Grønland, vol. 24, 1899.
3. Hlawatsch, C., Bemerkung zum Aragonit von Rohitsch, Natrolith und Neptunit von San Benito: Min. pet. Mitt., vol. 28, 1909, p. 293.
4. Louderback, G. D., and Blasdale, W. C., Benitoite, its paragenesis and mode of occurrence: Bull. Dept. Geology Univ. California, vol. 5, 1909, p. 331.
5. The present paper.

ORBICULAR GABBRO FROM PALA, SAN DIEGO COUNTY, CALIFORNIA.

A large number, a hundred or more, of what seemed concretions, were found lying loose on the summit of Hiriart Hill, near Pala, San Diego County, Cal. The writer's attention was called to them by Mr. F. M. Sickler, of Pala, who found them while exploring the hill for spodumene (kunzite). Many of them are broken, and an examination of one of them showed the apparent concretions to be the orbicules of an orbicular phase of the hornblende gabbro which forms this hill. This orbicular phase has weathered away, leaving behind nothing but these hard balls. Careful search of the rock revealed two or three poorly developed orbicules in the gabbro, but the main mass of the original orbicular rock has entirely disappeared. These orbicules have an average diameter of 2 to 2½ inches and vary somewhat in shape, rarely being regularly elliptical, but usually being of a distorted spherical shape.

The center is occupied by coarse-grained feldspar and some ferromagnesian minerals, which are surrounded by radiating prisms that can not be determined by the eye alone. The radiating mass is black in spots and the orbicule always shows a brownish border a millimeter or two wide, which is merely a zone of weathering. The entire orbicule is somewhat altered, brownish stains being common throughout. The orbicules have no concentric structure except the outer zone of weathering.

Microscopically, the minerals present are seen to be olivine, hypersthene, hornblende, feldspar, and iron oxides, such as magnetite and limonite. The olivine occurs in irregular masses nearly always surrounded by green hornblende. It is full of cracks, and near the edge of the orbicule it is much altered to iron oxide. It is colorless, nonpleochroic, with a very high relief and birefringence. The hypersthene is strongly pleochroic (from pink to colorless to pale green) and shows a high relief with low birefringence. It is in places surrounded by green hornblende. The hornblende occurs as a border around the olivine and hypersthene and also as small shreds of original mineral. It is generally green but becomes slightly brownish in places. It is commonly altered to chlorite. The feldspar is labradorite with symmetrical extinctions of about 37°.

The radiated structure is caused by the formation of long narrow masses of olivine, hypersthene, and hornblende, the olivine being the most abundant. They are irregular in their shape and show no definite boundaries. They are in general continuous for some little distance, but many are formed of pieces lying in a straight line but not connected. The green envelope or rim of hornblende commonly surrounds the olivine, and a number of specimens were noticed where a border of pink hypersthene separated the hornblende from the olivine. Where there is also a fringe of deep green chlorite surrounding the hornblende the combination makes a very pretty section. In some specimens it seems that the hypersthene alters directly to chlorite. The orbicules are not so perfectly developed as those described by Lawson[1] from Dehesa, San Diego County. The concentric structure there found is entirely lacking in the Pala rock, while the radiated structure is but poorly developed. One of the most interesting things about the Pala orbicular rock is its peculiar mode of occurrence, the orbicules lying loose in the soil instead of being embedded in the solid rock as at Dehesa.

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[1] Lawson, A. C., The orbicular gabbro at Dehesa, San Diego County, Cal.: Bull. Dept. Geology Univ. California, vol. 3, No. 17, 1904, pp. 383–386.

THE REFRACTIVE INDEX OF OIL OF CINNAMON.

INTRODUCTION.

The use of organic liquids of known refractive index (n) for determining the index of refraction of a mineral has reached a very extensive application in late years. Numerous papers have appeared recently, several by F. E. Wright, which have set forth the different methods of using the liquids. One of the commonest liquids is oil of cinnamon, which is easily obtainable, has a rather high index (1.6), and mixes easily with oil of cloves ($n = 1.53$) and oil of cedar ($n = 1.51$) to form a series which covers especially the row of plagioclase feldspars, a group of minerals very important in petrography.

Having prepared a large number of these solutions for geologists of the survey, the writer observed that the cinnamon oil varied in refractive index even while the measurement was in progress. If this variation was at all large it would preclude the use of the oil, and a detailed examination was therefore undertaken to determine the variation and to decide whether or not the oil was suitable for a standard measure. It was intended to subject to such an examination all the liquids commonly thus used, but lack of time has necessitated the postponement of the investigation. As soon as opportunity is presented, however, the study will be completed in order to furnish the information necessary for the use of the several liquids. This paper on the oil of cinnamon serves, therefore, as an introduction to the subject and shows the necessity for a complete knowledge of fundamental data.

GENERAL DESCRIPTION.

Cinnamon oil is obtained from the inner bark of a tree (*Cinnamomum zeylanicum*, belonging to the natural order Laurineæ) indigenous to Ceylon, but now also grown in Brazil, the West Indies, Egypt, Java, and on the Malabar Coast; Ceylon, however, produces by far the best quality. Cassia cinnamon and saigon cinnamon are obtained from different species of *Cinnamomum*, and the oils derived therefrom differ chemically from the true Ceylon oil of cinnamon. The cinnamon bark contains a volatile oil (oleum cinnamoni), tannin, sugar, and mannite. By distillation from one-half to 1 per cent of oil of cinnamon is obtained. The color of the fresh oil is yellow, but it deepens by exposure to air, becoming browner.

The oil consists chiefly of cinnamic aldehyde, $C_6H_5.CH.CH.CHO$, with smaller quantities of cinnamic acid, $C_6H_5.CH.CH.CO_2H$. Thorpe[1] mentions, in addition, the presence of a small quantity of a lævogyrate hydrocarbon. Cinnamic aldehyde[1] melts at −7.5° C., and is decomposed by boiling at atmospheric pressure. Its density is about 1.05, and refractive index about 1.61. By oxidation on exposure to air it forms cinnamic acid, which sometimes crystallizes from oil of cinnamon. Cinnamic acid forms colorless monoclinic prisms, which melt at 133° and boil at about 300° with or without decomposition according to the physical conditions. It is easily decomposed into styrene, $C_6H_5.CH.CH_2$, and carbon dioxide, CO_2. Oxidizing agents convert the acid first into benzoic aldehyde and then into benzoic acid.

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[1] Thorpe, T. E., Dictionary of applied chemistry, vol. 3, 1893, p. 12.

The above description of oil of cinnamon and its chief constituent, cinnamic aldehyde, which readily oxidizes to cinnamic acid, clearly shows how unstable a liquid it is, and therefore how unsuitable for any purpose requiring a medium of constant physical properties.

MEASUREMENTS OF REFRACTIVE INDEX.

The first series of measurements were made to determine the variation of the refractive index according to the temperature. For this purpose the small bottle with a thermometer stopper combined with the Abbe-Zeiss refractometer was employed. This was cooled in ice to about 0° and then placed on the glass hemisphere of the refractometer and the readings taken when the thermometer showed the desired temperature. By the use of the micrometer tangent wheel, which gives readings to 6 seconds, the measurements could easily and quickly be made. The oil of cinnamon showed practically no dispersion, and the values given for sodium light represent closely the index for daylight. No difference in the value of the index could be detected by using red lithium or green thallium light. The values of the index of refraction (*n*) for yellow sodium light, as measured, are shown below for the different temperatures.

Values of index of refraction of oil of cinnamon for different temperatures.

Temperature.	*n.*	Temperature.	*n.*	Temperature.	*n.*
° *C.*		° *C.*		° *C.*	
6	1.5996	13	1.5978	21	1.5942
7	1.5995	14	1.5973	22	1.5938
8	1.5991	15	1.5970	23	1.5936
8½	1.5989	16	1.5966	24	1.5929
9	1.5989	17	1.5958	25	1.5926
10	1.5983	18	1.5956	26	1.5921
11	1.5979	19	1.5949	27	1.5917
12	1.5976	20	1.5946	....	....

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[1] Beilstein, F., Handbuch d. organischen Chemie, vol. 3, 1897, p. 58.

These values are plotted and the resulting straight line shown in figure 3. From the readings, with a temperature variation of 21°, the refractive index varies from 1.5996 at 6° to 1.5917 at 27°. Therefore there is a decrease in the index of 0.00037 for every rise of 1°. From the plotted line (fig. 3) the refractive index at 0° is found to be 1.6022, and at 30° it is 1.5907, a change of 0.0115 for 30° change in temperature. From these values it is found that a change of temperature of 1° causes the solution to vary 0.00038 in the index. This change is reciprocal—that is, as the temperature increases the index of refraction decreases. The amount may be given as 0.0004 for a change of 1°.[1]

The variation in temperature at different seasons is therefore sufficient to cause an appreciable change in the index of refraction of the oil of cinnamon. Even during the day the variation in temperature is enough to markedly change the value. The following table gives the values for n at three different temperatures, which are often reached indoors at Washington during the year:

Variation of index of refraction of oil of cinnamon.

Temperature, Fahrenheit.	Temperature, centigrade.	n (Oil of cinnamon).
°	°	
100	38	1.5877
70	21	1.5942
50	10	1.5983

Another cause of variation, and one that is much more detrimental to the use of oil of cinnamon as a liquid of known refractive index, is its variability on exposure to air. This is owing to the oxidation of the cinnamic aldehyde to cinnamic acid. That this change is very rapid and also important is shown by the following table, which represents three sets of experiments. A drop of the oil was placed on the glass hemisphere of the refractometer and exposed to the air, readings being taken at definite time intervals. An exposure of only half a minute is sufficient for the index to increase 0.001 in value.

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[1] The variation for nitrobenzol is likewise 0.0004 for 1° change in temperature. Zeitschr. Kryst. Min., vol. 44, 1908, p. 620.

Change of refractive index of oil of cinnamon due to oxidation.

Time of exposure.	Gain in refractive index.		
	1	2	3
½ minute	0.0012	....	0.0009
1 minute	18	0.0015	15
2 minutes	27	24	24
3 minutes	32	27	29
4 minutes	35	30	32
5 minutes	38	....	36

Therefore in 5 minutes the solution increases nearly 0.004 in value. One set of observations (the third), showing the change in index on exposure to air, is given below, and the other values are combined in the curve shown in figure 3.

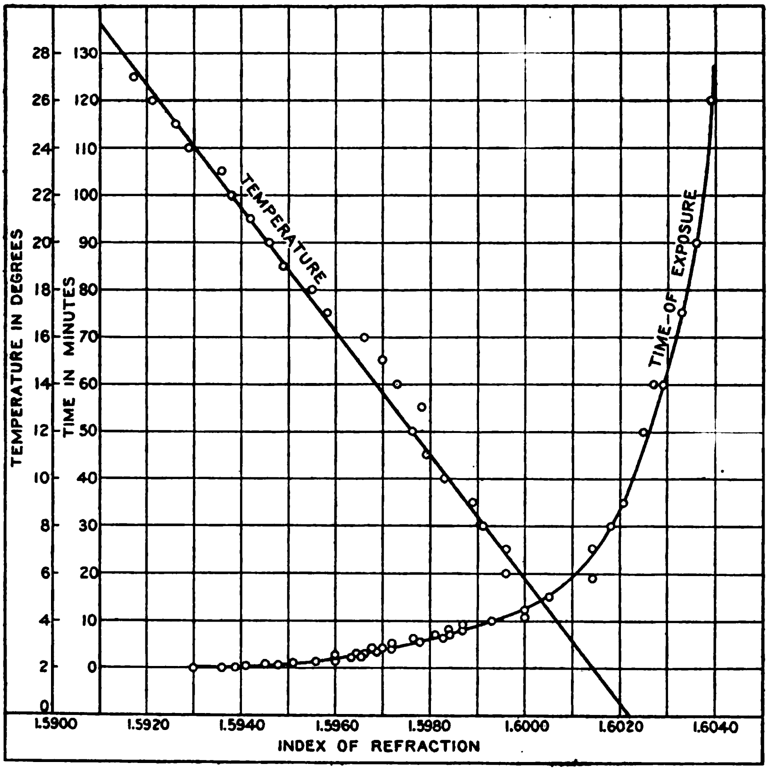

FIGURE 3.—Variation in index of refraction for oil of cinnamon.

Values of refractive index of oil of cinnamon on exposure.

Time of exposure in minutes.	Refractive index.	Time of exposure in minutes.	Refractive index.
0	1. 5936	10	1. 5993
½	45	11	1. 6000
1	51	12	00
2	60	15	05
3	65	19	14
4	68	25	14
5	72	30	18
6	77	35	21
7	81	50	25
8	84	60	27
9	87	75	33

As may be seen by reference to the curve of figure 3, the change in refractive index is very rapid for the first 10 minutes; then it gradually decreases in rapidity but still slowly gains even after an hour's exposure. The most rapid change occurs in the first 5 minutes, when a gain of nearly 0.004 takes place. After 10 minutes the total change is 0.006, after 20 minutes 0.008, and after an hour's exposure 0.009. The change then progresses slowly, and probably increases till the maximum is reached, which is probably about 1.615, though the writer does not know if this value has been determined. This would be a solution of cinnamon aldehyde saturated with cinnamic acid, and Wright and Larsen[1] give 1.615 for the refractive index of cinnamon aldehyde.

SUMMARY.

The results here given show that oil of cinnamon undergoes a marked change of refractive index on exposure to air. During 5 minutes, a time which may well be consumed in manipulation, the refractive index of the oil increases by 0.004. The variation of the index for a change in temperature of 1° is about 0.0004, the variation being reciprocal. The solution should therefore be standardized for a certain temperature and correction made for any variation therefrom. However, the variability due to oxidation is much greater, rendering oil of cinnamon unsuitable for any accurate work. The only known way to obviate this effect is to have the oil form a saturated solution of cinnamic acid in the cinnamic aldehyde, and a long exposure to air is necessary to obtain this. The best procedure where accuracy is essential is to avoid the use of oil of cinnamon altogether.

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[1] Wright, F. E., and Larsen, E. S., Optical study (on diopside, etc.): Am. Jour. Sci., 4th ser., vol. 27, 1909, p. 35.

INDEX OF REFRACTION OF CANADA BALSAM.

The refractive index of Canada balsam, as it occurs in the thin sections made for the United States Geological Survey, was determined on the request of Mr. F. C. Calkins, who had found[1] that the index, or n, was not absolutely constant, but varied between two extremes. By the examination of 300 slides he found n to reach and even slightly exceed ω of quartz (1.544), though n was found greater than 1.544 only in the proportion of one slide in a hundred. The excess was very small and the balsam was decidedly yellow. The lowest value found by him was about $1.535 \pm .002$.

The value of n for sodium light was determined with an Abbe-Zeiss refractometer by total reflection on three sets of slides, these being (1) not cooked as much as usual, (2) cooked ordinarily, and (3) overcooked. The differences found between (1) and (2) are very slight and, in fact, the individual values show almost as much variation as that between the groups. The values obtained for n are:

Values of refractive index for Canada balsam.

1	2	3
1. 539	1. 536	1. 543
1. 538	1. 538	1. 540
1. 539	1. 539	1. 540
		1. 542
		1. 541

The average values are for (1), 1.5387; for (2), 1.5377; for (3), 1.5412, or, as the average of all, 1.5395, which is almost identical with the value (1.5393) given by Becker[2] in 1898. A determination of n in a slide six years old gave the value 1.5390. These values show that, in general, n lies very close to 1.539 and that this value may well be used in a study of a thin section, though the actual possible variation was found by Mr. Calkins to be from 1.535 to 1.545, the extreme values, however, being but seldom reached. The uncooked liquid balsam has a refractive index of 1.524, which, after cooking, rises to 1.54. The older the slide the higher becomes the index of the balsam, and after some time, especially if the slide is exposed to the air, the index rises toward the highest value, or 1.545.

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[1] Science, vol. 30, p. 973, Dec. 31, 1909.

[2] Am. Jour. Sci., 4th ser., vol. 5, 1898, p. 349.

SIDERITE AND BARITE FROM MARYLAND.

SIDERITE.

OCCURRENCE.

A number of specimens of small splendent crystals of siderite were obtained through the courtesy of the Foote Mineral Co. of Philadelphia, the locality being given as "within 2 miles of Frostburg, Md." The crystals are very small and are deposited in great numbers on a massive gray siderite rock. A very striking feature of the siderite crystals is their splendent play of colors. Though brown in color, they are very iridescent, the light reflected from their surface being of all colors. Associated with the siderite crystals and intermingled with them are numerous small barite crystals.

The matrix is a compact impure iron carbonate, having a specific gravity of 3.7, in which are embedded occasional masses of white, opaque barite, showing good cleavage. In the rock are numerous cavities lined with siderite and barite crystals derived from the massive rock, the specimens forming geodes.

The crystals of siderite vary from exceedingly minute ones up to those of a millimeter in length and breadth. Most of them are attached to the matrix by one end, though many irregularly scattered through the mass are attached at both ends. The entire layer of crystals is about a millimeter in thickness.

CHEMICAL COMPOSITION.

A number of the crystals were broken from the matrix. From these some were very carefully selected and were freed from a small amount of barite by the electromagnet. About one-tenth of a gram of pure crystals was finally obtained, each crystal having been picked out and found to be free from any foreign matter. It was noted that the crystals did not possess a uniform color, some of them being a much lighter brown than others. It was at first thought that the lighter colored ones contained calcium or magnesium, but such was found not to be the case. The difference between the shades of color is probably due to the varying amount of ferric iron in the crystals.[1] The selected crystals were dissolved in hydrochloric acid and the iron precipitated with ammonia and weighed. Tests made for manganese, calcium, and magnesium proved their absence. The weighed iron oxide was fused with sodium bisulphate, reduced and titrated with potassium permanganate, giving practically the same figure. There was found 62.21 per cent FeO (calculated 62.07 per cent FeO). The crystals are therefore pure iron carbonate and well suited for obtaining crystallographic constants for siderite.

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[1] Siderite should be white if chemically pure. The brown color so often observed may be due to a very slight oxidation of the ferrous iron to the ferric condition, which ferric compound then remains in the ferrous carbonate in a state of solid solution.

CRYSTALLOGRAPHY.

FORMS.

The siderite crystals have a rather unusual habit for that mineral, the dominant form being the scalenohedron $v\{21\bar{3}1\}$, the common form for calcite. A number of other forms are present, and a very marked feature of these crystals is that there are concave rounded hollows in approximately the places where the *a* face should come. The crystals are highly polished and seemingly should give perfect reflections, but on examining them on the two-circle goniometer it was found that the faces were not as perfect as was at first thought, chiefly because some of the large scalenohedral faces appear broken and the parts slightly displaced, yielding more than one signal several minutes apart. The crystals were mounted in polar position on the two-circle goniometer, and so adjusted that on turning the vertical circle (the horizontal one being clamped) the reflections from the several faces of each form fall, respectively, in a vertical line coinciding with the vertical cross hair. After the crystal was adjusted as perfectly as possible, the reading on the horizontal circle was taken for each face, the signal being brought to the exact center of the field in each case. The forms present are: $r\{10\bar{1}1\}$, $l\{70\bar{7}5\}$, $k\{50\bar{5}2\}$, $f\{02\bar{2}1\}$, $v\{21\bar{3}1\}$, $y\{32\bar{5}1\}$.

The form $l\{70\bar{7}5\}$ occurs but once as a small face below $\{10\bar{1}1\}$ but larger than that face. The reflection was fair.

Measured and calculated angles of the form l $\{70\bar{7}5\}$ *on siderite.*

	ϕ		ρ	
	°	′	°	′
Measured	0	14	52	49
Calculated[a]	0	00	53	07

[a] From element derived by writer.

The form $k\{50\bar{5}2\}$ occurs as a minute line face, somewhat rounded and truncating the edge of the scalenohedron $v\{21\bar{3}1\}$. The measurements showed that the ρ angle was about 68°, though no accurate measurement could be obtained (calculated $\rho = 67° \ 12'$). The unit rhombohedron r occurs on nearly all of the crystals as small faces truncating the apex of the crystals. The new scalenohedron $y\{32\bar{5}1\}$ occurs on all the crystals and is a characteristic form for this locality. Though it varies in size, becoming relatively wide and short or narrow and long, its general size is shown in figure 4.

The zone $vyy^{vi}v^{vi}$ is in some specimens somewhat striated between y and y^{vi} and by using the dot signal it was seen that there was a maximum of brightness in the position required for the faces $\{7.6.\overline{13}.1\}$ and $\{11\bar{2}0\}$. It could not be shown, however, that these faces were actually present. The form $f\{02\bar{2}1\}$ occurs as broad dull faces giving no reflection and only an almost imperceptible haze of light. Measurements of the ρ angle gave values from 59° to 62° (calculated 62° 17′).

The concave hollows give an indefinite blaze of light in the zone of the negative rhombohedrons, about 80° from the base, so that they do not reach down to the prism zone. A study of these hollows on the goniometer, the dot signal being used, showed that they consisted of vertical striations approximating in the center to the form $\{06\bar{6}1\}$ and at the extreme edge to $\{11\bar{2}0\}$ with many forms in between these.

Figure 4 is an attempt to illustrate the actual appearance of these crystals showing particularly the concave hollows. The indentations in the orthographic projection are somewhat exaggerated. With the exception of these and the broad, dull faces, the crystals are highly polished and do not show any etching. It seems more plausible to regard these hollows as the result of an incomplete or skeletal growth rather than to consider them as the result of etching. They are in a way analogous to the hopper-shaped crystals of sodium chloride in which the two planes (001) and (100) (in one zone) alternate and the resultant hollow has in cross sections a V shape. In the siderites, however, instead of an alternation of the two planes $\{06\bar{6}1\}$ and $\{11\bar{2}0\}$, there is a gradation from the prism to the rhombohedron, and the result is a rounded hollow instead of a sharply angular one.

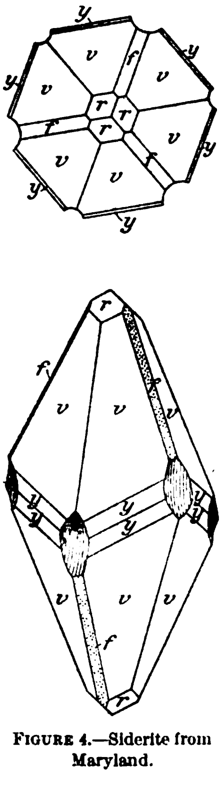

FIGURE 4.—Siderite from Maryland.

ETCH FIGURES.

A cleavage piece of siderite was left standing in very dilute hydrochloric acid for several days and then examined under the microscope, when well-defined etch figures could be observed. As shown in figure 5, these are triangular in shape and possess a plane of symmetry parallel with the shorter diagonal of the cleavage rhomb of siderite. They resemble in symmetry the figures shown in Miers's Mineralogy (p. 112) for calcite and not those given for dolomite. The symmetry of siderite is the same as that of calcite and not that of dolomite—a conclusion sustained by the forms of the crystals.

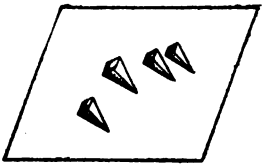
FIGURE 5.—Etch figures of siderite.

VALUE FOR *c* AXIS.

Although siderite is a common mineral, good crystals are rare and the literature is very poor in accurate crystallographical data. The only value given for the axial ratio, which is adopted in all books, is one obtained in 1812 by Wollaston. His statement in regard to siderite is as follows:[1]

> I have examined various specimens of this substance, some pure white, others brown, some transparent, others opaque. That which gives the most distinct image by reflection is of a brownish hue, with the semitransparency of horn. It was obtained from a tin mine, called Maudlin mine, near Lostwithiel, in Cornwall. By repeated measurements of small fragments of this specimen the angle appears to be so nearly 107° that I can not form any judgment whether in perfect crystals it will prove to be greater or less than that angle.
>
> In this instance the carbonate of iron is nearly pure, and so perfectly free from carbonate of lime * * *.

The measurements of the faces giving good reflections were used for calculating a value for the *c* axis. The angles for the same form varied somewhat on different crystals, though the values obtained from the measurements of different forms agree very well with each other. From the average reading the following values were calculated:

Calculation of c axis of siderite.

10 measurements of r $(10\bar{1}1)$	$c = 0.82352$
27 measurements of v $(21\bar{3}1)$	$c = .82463$
16 measurements of y $(32\bar{5}1)$	$c = .82311$
Average	$c = .8240$

An attempt was made to measure the cleavage angle directly, but it was found that the resultant cleavage faces were never perfectly plane, with the result that each face gave several signals.

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[1] Phil. Trans., 1812, p. 159.

After this value for c was obtained and found to be different from the commonly accepted value, 10 more crystals were measured, and after the greatest care in so adjusting each crystal that the reflections from the scalenohedral faces of v fell as nearly as possible in a straight line each reflection was carefully measured. In the case of more than one signal the extremes were measured and the average taken. The average value for the ρ angle for each crystal (six faces) is:

Measurements of ρ for v $\{21\bar{3}1\}$, siderite.

°	′	°	′
68	14	68	21
68	26	68	27
68	18	68	20
68	15	68	19
68	16	68	29

Average 68° 20½′; c=.8243.

The values for the two extremes, 68° 14′ and 68° 29′, are: c=.8197 and c=.8302.

Taking the average of the value found from r, v, y, namely, .8240, and that found from the 10 crystals, namely, .8243, we get as a value for the c axis for siderite of known purity c=.8241. Whether or not this value is more accurate than the one commonly accepted is difficult to decide. Palache[1] has measured some crystals which gave values agreeing with the commonly accepted value of the c axis, so that the question as to the true value of the fundamental crystallographic constant of siderite is one which still remains to be determined by more measurements.

BARITE.

OCCURRENCE.

The barite occurs in three different forms on the specimens seen by the writer. The first is the white massive form, which is often embedded in the matrix. It is generally opaque and shows a good cleavage. The second form occurs as an opaque white efflorescence, which is composed of an aggregate of minute crystals. The third form is present in transparent colorless crystals, some of which reach a length of several millimeters, though most of them are rather smaller. The largest ones seen were about a centimeter long and a millimeter or two thick. On some specimens these transparent crystals are attached by one end to the massive barite and form a fringe, as it were, around it, the crystals standing normal. This occurrence is very suggestive of a secondary formation of the crystals—that they are derived from the massive barite in the matrix. The large clear crystals are probably a more perfect development than the white efflorescence and both are doubtless derived from the massive barite. In the massive barite there are no siderite crystals, though small fragments of the matrix are included therein;

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[1] Palache, C., Mineralogical notes: Am. Jour. Sci., 4th ser., vol. 24, 1907, p. 254.

and in the efflorescence crystals of siderite are commonly inclosed, and the clear large barite crystals are intermingled with those of siderite.

CRYSTALLOGRAPHY.

The crystals of barite are of especial interest, as they are of an uncommon habit—prismatic, elongated parallel to the vertical axis. Such crystals have been noticed before, but they are not the common form for barite.

The faces of the crystals are highly polished and gave excellent signals. The prism zone is striated on some specimens, especially on the macropinacoid, though for the most part the zone is not striated and each face is distinct and plane. The forms present are as follows:

Forms of barite.

c{001}
b{010}
a{100}
x{130}
B{370}
n{120}
N{230}
m{110}
η{320}
λ{210}
o{011}
d{102}
l{104}
v{115}
q{114}
f{113}
r{112}
R{223}
z{111}
Y{551}
y{122}

The prism *B*{370} occurs twice on two crystals as small faces, giving a fair reflection. The ϕ angles measured are as follows: 28° 09′, 27° 52′, 27° 45′, 27° 41′ (calculated, 27° 45′). The form was first noted by Düsing[1] and classed as doubtful by Dana; it is not included in Goldschmidt's Winkeltabellen.

The pyramid *Y*{551} measured (ρ): 84° 55′, 84° 58′, 84° 08′, 84° 45′ (calculated (ρ) 84° 45′). It is present as very narrow and small faces.

The general ideal view of these crystals is shown in figure 6. Some of the crystals are flat, parallel to the macropinacoid, but most of them are of equal diameter horizontally. Some of them, too, have one side of the terminated end much larger than the other side, but in general the crystals are fairly symmetrical.

On account of the excellence of the signals an axial ratio was calculated from the measurements. A value for *a* was obtained from the prism faces, and using this value the value for *c* was obtained from the pyramids and domes (the crystals being measured on the two-circle goniometer). From 44 values for *a* and 70 values for *c*, the values $a = .8146$, $c = 1.3126$ are obtained, and these are very close to the accepted values.

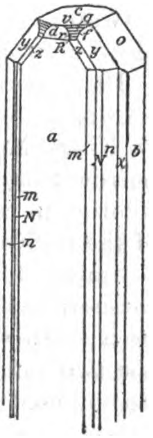

FIGURE 6.—Barite from Maryland.

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[1] Zeitschr. Kryst. Min., vol. 14, 1888, p. 481.

NOTES ON PURPURITE AND HETEROSITE

INTRODUCTION.

The mineral purpurite, a hydrous manganic ferric phosphate, $(Mn,Fe)_2O_3.P_2O_5.H_2O$, was first found in North Carolina by L. C. Graton and a description of it was published[1] in 1905. On account of its rich purple or dark-reddish color it was named purpurite, from the Latin *purpura*, purple or dark red. Since the original discovery the same mineral has been found at several other localities.

Lacroix, to whom some of the original purpurite from North Carolina was sent, has stated[2] that purpurite is identical with heterosite. In view of this the writer proposes to restrict the name heterosite to the ferric phosphate and the name purpurite to the manganic phosphate. Heterosite predominates (76 per cent) in the material from South Dakota, but purpurite predominates (65 per cent) in that from North Carolina.

PURPURITE FROM NORTH CAROLINA.

OCCURRENCE.

Graton gives the following description of the occurrence and physical properties of the mineral:

The mineral purpurite is found in small irregular masses in the tin-bearing pegmatite dikes and in the near-by schist at the Faires mine at Kings Mountain, Gaston County, N. C. It generally occurs in narrow lenses or veinlets, and appears to have been deposited from solution in cavities. Occasionally, however, it is found in the midst of the pegmatite as if it were an original mineral.

Among the primary minerals of the tin-bearing pegmatites are cassiterite, tourmaline, apatite, spodumene, lepidolite, and a yellowish-brown, lithia-bearing phosphate, which is doubtless lithiophilite. The last two minerals have been found only in small quantities. Partially decomposed specimens of this pegmatite frequently show much manganese dioxide as thin mammillary coatings on the other minerals. Ilmenite is often included in crystals of cassiterite. It is evident, therefore, that the elements manganese and iron (as monoxides), lithium, and phosphorus (as phosphate) were primary components of the pegmatite magma.

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[1] Graton, L. C., and Schaller, W. T., Purpurite, a new mineral: Am. Jour. Sci., 4th ser., vol. 20, 1905, pp. 146-151.

[2] Lacroix, A., Minéralogie de la France, vol. 4, 1910, p. 469.

The mineral presumed to be lithiophilite is always surrounded by a coating of black, secondary material. In one case, a narrow zone of purpurite was found between the lithiophilite and the black mineral. It is believed that this single occurrence furnishes the explanation of the origin of purpurite. A lithia-manganous-ferrous phosphate, probably lithiophilite, was attacked by oxidizing solutions. The lithia was almost wholly carried away, and of the remaining elements the iron and manganese were oxidized to the state of sesquioxides and were recrystallized with the phosphoric acid and water to form purpurite. The trace of lithium which this mineral contains is a remnant of that from the lithiophilite. In some cases the recrystallization took place without transportation of the materials, forming pseudomorphous replacements, but in general the materials were carried in solution to cavities and there deposited.

PHYSICAL PROPERTIES.

Purpurite is orthorhombic, but no specimens from North Carolina have been found which show crystal outline. A cleavage which is probably pinacoidal is rather well developed, but many of the cleavage surfaces are curved as if the orientation of adjoining grains were not exactly the same. A second cleavage, presumably at right angles, is considerably less distinct. The mineral has an uneven fracture and is rather brittle. It is scratched without difficulty by the knife, but on the other hand just scratches fluorite; hence it has a hardness of 4–4.5. In color the mineral is a rich deep red or reddish purple, sometimes with a slight bronzy iridescence, and not uncommonly darker on the cleavage planes. The powder and the streak have a decided purple or deep rose color. The mineral has a peculiar satiny luster or sheen more noticeable on fracture surfaces than on cleavage planes.

Although very thin pieces of purpurite are transparent, the ordinary thin section allows but little light to pass through. The colors in transmitted light are very beautiful, the mineral being strongly pleochroic. Parallel to the cleavage the color is deep scarlet inclining to rose red, but across the cleavage the absorption is greater and the color becomes a beautiful purple. This absorption, it will be noticed, is similar to that of tourmaline and a few other minerals, in which the greatest absorption is at right angles to the direction of cleavage or elongation. Extinction is generally parallel; an inclination up to 3° or 4°, which has been observed in a few instances, is probably due to the orientation of the sections examined. It may be, however, that the mineral is monoclinic with a very small extinction angle. Transparent sections were not of sufficient size to give an interference figure. No sections showed the intersecting cleavages, and in all the sections examined the traces of the cleavages are parallel to the direction of greater elasticity of the section; so if the mineral is biaxial, the intersection of the cleavages is parallel to a. This is also the direction of least absorption. The refractive index is somewhat greater than that of Canada balsam, and probably lies between 1.60 and 1.65. The difference of the indices or the double refraction is high, and although it could not be measured at all accurately is probably not much below .060. One effect of this high double refraction on the very thin sections examined is that under crossed nicols the mineral appears to transmit as much and as brilliant light as without polarization. The red interference colors are very striking.

All specimens of the purple mineral are covered or surrounded by a greater or less thickness of a black or brownish-black material of pitchy luster and uneven or subconchoidal fracture. This material,[1] which is soluble in hydrochloric acid, contains iron, manganese, phosphoric acid, and water. Under a lens the black material can be seen to encroach upon the purpurite, eating in along the cleavage planes and gradually replacing the purple mineral. Under the microscope it appears to be a definite mineral, having an imperfect cleavage, and a brownish-yellow color in transmitted light. Extinction is nearly or quite parallel to the cleavage, and the trace of the cleavage is the direction of least refractive index of the sections examined. Pleochroism is distinct, and, as in purpurite, absorption is greatest across the cleavage. The index of refraction is greater than that of Canada balsam, and the double refraction is probably rather high.

CHEMICAL COMPOSITION.

About a gram of pure material was separated, which was divided into several portions, using about one-fifth of a gram for each determination. The most interesting part of the analysis was to determine the state of oxidation of the manganese.

When the mineral is treated with hydrochloric acid, chlorine is readily given off. The manganese present therefore can not be in the manganous state, and the absence of ferrous iron and the presence of ferric iron suggested that the manganese was present as a manganic salt. Such was found to be the case.

A fifth of a gram was dissolved in sulphuric acid with a known amount of ferrous ammonium sulphate. All precautions were observed to exclude air, the entire operation being conducted in an atmosphere of carbon dioxide. The water used had been boiled and cooled out of contact with air. Just before the iron sulphate was introduced into the flask containing the mineral an equal quantity was removed from the stock solution and titrated with permanganate.

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[1] Probably the pseudoheterosite of Lacroix, op. cit., p. 469.

Thus the amount of ferrous iron introduced into the flask with the mineral was known. After the mineral had been decomposed by the sulphuric acid, the flask was cooled and the solution titrated, the amount of iron sulphate oxidized by the liberation of oxygen from the mineral being determined in this way. From these data the amount of Mn_2O_3 was calculated and found to be 30.47 per cent.

A second sample was decomposed by hydrochloric acid and the chlorine evolved passed into a solution of potassium iodide. The liberated iodine was then titrated with sodium thiosulphate, the latter being standardized with pure copper. Calculating from the results obtained, the amount of Mn_2O_3 was found to be 27.93 per cent. Though these results vary somewhat, yet, considering the small amount of material used (one-fifth of a gram) and the many operations necessary, the agreement is as close as could be expected. The average of the two results is 29.20 per cent.

A direct determination of the total manganese, weighed as anhydrous sulphate, gave as the amount of Mn_2O_3 in the mineral 29.35 per cent, which agrees almost exactly with the average of the two indirect determinations.

The remaining constituents were determined as follows: A portion of the mineral was dissolved in hydrochloric acid and a known weight of iron added (as ferric chloride). A basic acetate separation was then made and the solution boiled for15 minutes, which, according to Bunsen, will precipitate all the phosphoric acid with the iron and will not precipitate any manganese. The precipitate was dissolved in hydrochloric acid, and reprecipitated by ammonia, after the addition of some ammonium chloride. The two filtrates were united, manganese precipitated by hydrogen sulphide, and finally weighed as anhydrous manganese sulphate. Calcium was then thrown out, dissolved, and reprecipitated, and magnesia found to be absent. The iron-phosphate precipitate was dissolved in hydrocholoric acid and divided into two portions. In one portion the iron and phosphoric acid were precipitated by ammonia and weighed. This was then fused up with sodium bisulphate and tested for manganese with silver nitrate and ammonium persulphate. None was present. In the second portion the iron was reduced by hydrogen sulphide and titrated with permanganate. Phosphoric acid was determined in the usual way and a second value obtained by the difference between the iron and the iron plus phosphoric acid. The alkalies were determined by the Lawrence Smith method. The final solution of chlorides gave a strong spectroscopic test for lithium. The water below 105° was determined directly, using a toluene bath. The total water was determined directly by heating in a glass tube, according to Penfield. The water is all given off at a low temperature, that at 105° being given off very readily and at one time. Further heating at 105° failed to remove any more. The values obtained are as follows:

Analysis and ratios of purpurite.

	1	2	3	Average.	Ratios.
Fe_2O_3	15.89	....	....	15.89	1.03 } 2.96
Mn_2O_3	29.35	30.47	27.93	29.25	1.93
P_2O_5	47.64	46.96	....	47.30	3.47
H_2O	5.26	....	....	5.26	3.04
CaO	1.48	....	....	1.48	.27 } .41
Na_2O	.84	....	....	.84	.14
Li_2O	Trace.	....	....	Trace.	....
Insol	.52	....	....	.52	....
				100.54	

The amount of water given off at 105° is 3.31 per cent. As all of the water is so readily given off, it is most probably present as water of crystallization.

As the calcium and soda require some phosphoric acid, the ratio of $R'''_2O_3 : P_2O_5 : H_2O$ is approximately 3 : 3 : 3. Combining the ratio of the calcium and sodium with that of the iron and manganese and reducing these to their hydrogen equivalent, the ratio becomes:

$$H_{18\cdot53}P_{6\cdot94}O_{26\cdot64}2.04H_2O$$

or

$$2[H_{2\cdot97}P_{\cdot93}O_{4\cdot04}]\cdot92H_2O.$$

The formula for the mineral then becomes $R'''_2O_3.P_2O_5+H_2O$, or $R'''_2P_2O_8+H_2O$.

The exact state of combination of the calcium and sodium is unknown. They most probably represent some slight impurity. If the manganic and ferric oxides are isomorphous in the sense that manganous and ferrous oxides are, the ratio of Mn_2O_3 to Fe_2O_3 being nearly 2 : 1 is of no significance and the formula should be written $(Mn''', Fe''')_2O_3.P_2O_5.H_2O$, the mineral purpurite being near the manganic end of an isomorphous series having as its two end members:

$$Fe_2O_3.P_2O_5.H_2O$$
$$Mn_2O_3.P_2O_5.H_2O.$$

There are only a few hydrous phosphates of the normal division in which the base is trivalent, such as scorodite and strengite. All of these, however, contain more water than the mineral here described.

Though no manganic phosphates were noted in the literature, there are a number of arsenates mentioned as containing Mn_2O_3, with none of which, however, can purpurite be classed. Synadelphite, flinkite, arseniopleite, and perhaps hematolite, contain Mn_2O_3 with Al_2O_3 or Fe_2O_3, while in durangite and arseniosiderite, Mn_2O_3 is reported in small amounts.

The mineral fuses easily and readily gives off water in a closed tube, becoming yellowish brown. It is readily soluble to a clear solution in hydrochloric acid, and in nitric acid a black oxide of manganese is separated.

HETEROSITE FROM SOUTH DAKOTA.

Some specimens of ore found near Hill City, S. Dak., were seen to contain a considerable amount of heterosite,[1] and through the courtesy of Mr. J. N. Smith, who sent in the first specimens, a larger quantity of material was obtained. Almost all the fresh cleavage surfaces of the black iron manganese phosphate, which chiefly forms the ore, are covered with a film of heterosite. The black phosphate when broken transverse to the cleavage shows but little heterosite, which seems to be formed from the black mineral.

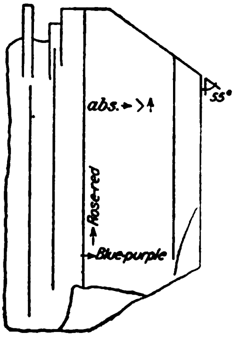

FIGURE 7.—Heterosite from South Dakota.

The properties of the mineral as seen under the microscope agree with those determined for purpurite from North Carolina. One small piece showing crystal outline was noticed and is shown in the accompanying sketch (fig. 7). The extinction is parallel and the pleochroism is as follows: Parallel to the cleavage lines (vertical direction), rose red; normal to the cleavage lines, blue purple. The absorption parallel to the cleavage lines (rose red) is less than that at right angles to this direction. On account of the frequent occurrence of small platy masses showing cleavage lines, the mineral has probably two cleavages at right angles to each other, one more perfect than the other. It is probably the imperfect one which is normal to the figure and whose traces show in the vertical lines.

A determination of the density was made, the value previously found from the small specimen of North Carolina material being unsatisfactory. The material was broken into small pieces and the fragments of heterosite picked out. The final sample was not pure, as a small amount of the black substance could not be separated. The density determination was made by weighing the mineral in water in a small test tube suspended from the balance arm. The result obtained is 3.40.[2]

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[1] First described as purpurite. Am. Jour. Sci., 4th ser., vol. 24, 1907, p. 152.

[2] Lacroix, A., Minéralogie de la France, vol. 4, 1910, p. 469, gives 3.27–3.52 for heterosite.

The sample was air-dried for several weeks and then analyzed, with the results given below:

Analysis and ratios of heterosite from South Dakota.

	Analysis.	Ratios.
P_2O_5	43.45	.306 =1
Fe_2O_3	38.36	.240
Mn_2O_3	12.08	.076 =1.06
CaO	1.37	.008
H_2O	4.82	.268 = .88
Insol	.19	
MgO, Na_2O, Li_2O	Trace	
	100.27	

The ratios agree fairly closely with those found in the original purpurite, giving as the formula of the mineral $(Fe,Mn)_2O_3,P_2O_5.H_2O$. The iron greatly predominates over the manganese in the South Dakota mineral, which is therefore called heterosite.

HETEROSITE FROM CONNECTICUT.

A small specimen from the well-known mineral locality of Branchville, Conn., was kindly furnished the writer by the late Prof. Penfield. This specimen is coated with a purple mineral whose optical properties as seen under the microscope agree well with those of purpurite.

Only a very small amount of fairly pure material (0.0197 gram) could be obtained for analysis. A direct determination of the water was made, but the phosphoric acid had to be determined by difference. The results obtained are as follows:

Analysis and ratios of heterosite from Connecticut.

	Analysis.	Ratios.
Fe_2O_3	27	17 32
Mn_2O_3	23	15
P_2O_5	[44]	31
H_2O	6	33
	100	

The ratios are nearly 1 : 1 : 1, giving the same formula as before, namely, $(Fe,Mn)_2O_3.P_2O_5.H_2O$.

PURPURITE FROM CALIFORNIA.

Purpurite or heterosite has been noticed on some specimens from San Diego County, Cal. These had been collected by the writer, and through the courtesy of Mr. F. M. Sickler, of Pala, several more specimens from this locality have been obtained. They are from one of the lithium-bearing pegmatite dikes on Hiriart Hill, Pala, San Diego County. The mineral occurs with lithiophilite, and possesses the same purple color as the North Carolina specimens. Under the microscope the appearance and properties of the mineral from the two localities are identical. There is, however, not enough of the California material for chemical examination.

CONCLUSION.

Considering now the three analyses from North Carolina, South Dakota, and Connecticut, it is seen that the iron and manganese vary reciprocally, so that the occurrences represent isomorphous mixtures of $Fe_2O_3.P_2O_5.H_2O$ and $Mn_2O_3.P_2O_5.H_2O$.

In the North Carolina mineral the manganese predominates and we have purpurite; in that from South Dakota the iron predominates and we have heterosite; and in the Connecticut mineral the iron and manganese are present in nearly equal amounts. These relations can also be shown by the following table:

Percentage composition of mixtures of purpurite and heterosite.

Locality.	Approximate content.	
	$Fe_2O_3.P_2O_5.H_2O$ (Heterosite).	$Mn_2O_3.P_2O_5.H_2O$ (Purpurite).
	Per cent.	*Per cent.*
North Carolina......	35	65
Connecticut.........	53	47
South Dakota.......	76	24

In the original paper describing purpurite the suggestion was made that the pure end members be called ferripurpurite and manganipurpurite. Since then the essential identity of the minerals with the French heterosite has been advocated by Lacroix, so that the names ferripurpurite and manganipurpurite should be replaced by the older names heterosite and purpurite, respectively. More accurately the North Carolina material should be called iron (or ferric) purpurite and that from South Dakota and from France manganese (or manganic) heterosite.

NOTES ON POWELLITE.

POWELLITE FROM LLANO COUNTY, TEXAS.

Specimens of the powellite from Baringer Hill, Tex., described in this paper were received through the kindness of Mr. Wm. E. Hidden and represent a small lot that was found in January, 1907. According to Mr. Hidden, who generously placed the material at the writer's disposal, the specimens are similar to those found by him in 1889 and referred to molybdite.[1] The reinvestigation of this mineral was undertaken because it had been suggested that it was probably a natural occurrence of the trioxide of molybdenum, the writer having shown in a previous paper[2] that molybdite was a hydrous ferric molybdate. (See also pp. 84–92.) Analysis showed, however, that this mineral from Baringer Hill is a calcium molybdate and is referable to powellite.

As received by the writer, the mineral is in loose pieces, some over a centimeter wide, associated with, coating, and in many specimens entirely replacing molybdenite. In fact, the powellite forms a pseudomorph after the sulphide of molybdenum, the foliated structure of the latter being frequently retained. The dirty white to gray mineral, some of which is stained brown by iron oxide, breaks up into small glistening scales which, when rubbed between the fingers, crumble to a pearly powder that adheres to the skin and resembles in appearance some varieties of fine-grained talc. Under the microscope the mineral shows double refraction, but no crystal outline. The individual crystal units are very minute, the specimens being aggregates of very fine scales.

A density determination was made on about 0.8 gram of the powdered sample. The pycnometer method was used and the determination was carried out with care at a temperature of 25°. The value obtained for the sample is 4.153, which, when corrected for impurities as described below, gives 4.23. Hidden[1] found the value 4.004, which would indicate that his sample contained more impurities than the writer's.

Analysis of this mineral gave the following results, the mineral dissolving readily in HCl. Qualitative tests failed to show the presence of any tungstic oxide. The mineral is difficultly fusible and gives at the most only a trace of water in the closed tube.

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[1] Am. Jour. Sci., 3d ser., vol. 38, 1889, p. 485.

[2] Am. Jour. Sci., 4th ser., vol. 23, 1907, p. 297.

Analysis of powellite from Texas.

CaO	27.46
MoO_3	67.90
Loss on ignition	2.33
MoS_2	1.50
SiO_2	.88
	100.07

The ratio of CaO to MoO_3 is 1:0.96, giving the formula $CaMoO_4$.

What is probably a similar occurrence of powellite has recently been described[1] as possibly a natural occurrence of MoO_3, the mineral differing in its physical properties from the hydrous ferric molybdate. The mineral forms a white or grayish alteration product of molybdenite which it sometimes covers and after which it is pseudomorphous, preserving the form of the molybdenite. The luster is pearly and the mineral is semitranslucent, difficultly fusible to a gray scoria; soluble in nitric acid, and does not contain any iron or water. The material was too scanty for analysis.

POWELLITE FROM NYE COUNTY, NEVADA.

The powellite from Nevada was received through Mr. F. L. Hess, of the United States Geological Survey, who states that the specimens were sent him by Mr. F. O. Byor, of Columbia, Nev. The locality is given as 2 miles south of Oak Springs, Nye County, Nev.

The powellite occurs in a vein about 1½ centimeters wide in a soft earthy mass, which seems to be an altered rock. In this rock are occasionally found irregular masses of powellite, some of which are several centimeters across. The mineral is dull in appearance, gray in color, and occurs in platy masses often bent and twisted in different directions.

Gray to white masses of scheelite are embedded in this vein of powellite and also occur as small masses and veins in the altered rock matrix. These masses of scheelite show good cleavage surfaces with highly vitreous to adamantine luster, many having also a decided greasy appearance. The association of scheelite with powellite side by side was thought to be most unusual, but other specimens showed that the powellite, like the Texas mineral, was secondary, being formed in place from molybdenite; it is in fact a pseudomorph after the sulphide of molybdenum. Some other specimens showed the various stages of alteration very well, the amount of unaltered molybdenite varying from a considerable quantity to almost none at all. The association of molybdenite with scheelite is well known and when the molybdenite alters to powellite, the association of powellite with scheelite necessarily follows. The agencies effecting the change from molybdenum sulphide to calcium molybdate are apparently without effect on the scheelite. This pseudomorphous character of the powellite accounts for its occurrence in platy masses, the structure of the original molybdenite being retained. On some of the specimens, notably those on which there is still a considerable amount of molybdenite remaining, the powellite has a reddish color due to iron stain.

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[1] Gagarine, G., Molybdite from the Ilmen Mountains: Bull. Acad. Imp. Sci. St. Pétersbourg, 6th ser., 1907, pp. 287-288.

The dull gray powellite can easily be separated by hand picking from the shining greasy scheelite and a sample so selected was used for analysis. A thin section showed, under the microscope, some quartz, hematite, and limonite as impurity.

The density of the mineral was determined by weighing a test tube containing about 6 grams of the mineral in water. The value obtained is 4.026, which, when corrected for impurities as described below, becomes 4.24.

The analysis yielded the following figures, the small amount of tungstic oxide present being probably due to admixed scheelite:

Analysis of powellite from Nevada.

CaO	26.44
MoO_3	62.43
Fe_2O_3	1.17
Loss on ignition	2.69
SiO_2	6.80
WO_3	Trace.
	99.53

The material insoluble in HCl was tested with HF and found to be almost entirely silica. The ratio CaO to MoO_3 is 1: 0.92, giving the formula $CaMoO_4$.

DENSITY OF POWELLITE.

The sample of powellite from Texas gave the value 4.153 as its density. This figure is corrected, on the basis of the following composition of the sample, to 4.23.

Mineral composition of sample of powellite from Texas.

Silica (density, 2.65)	0.88
Water (density, 1)	2.33
Molybdenite (density, 4.7)	1.50
Powellite	95.29
	100.00

The presence of the water as such is of course an assumption, and the final value, 4.23, is necessarily uncertain, depending on the assumptions made.

The powellite from Nevada gave 4.026 as its density, and from the analysis the composition of the sample was found to be as follows:

Mineral composition of sample of powellite from Texas.

Silica (density, 2.65)	6.80
Water (density, 1)	2.69
Iron oxide (density, 3)	1.17
Powellite	89.34
	100.00

Allowing for the impurities, the value is raised to 4.24, which, like the preceding case, is dependent on certain assumptions.

As powellite and scheelite are doubtless isomorphous, we may be justified in assuming that they have nearly the same molecular volume. Considering the molecular volumes as identical, and taking the gravity of scheelite as 6.14, the density of powellite then becomes 4.267, as calculated by Melville.[1]

As all previous analyses of powellite showed the presence of tungstic acid, the densities given are all too high for the pure calcium molybdate. The two values obtained by the writer, though uncertain (as they are based on some assumptions made in applying the corrections), agree so well not alone with each other, but also with the calculated value, that the average of the three values (4.24, 4.23, 4.27), namely, 4.25, may be taken as being very close to the true density of the pure calcium molybdate, $CaMoO_4$.

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[1] Am. Jour. Sci., 3d ser., vol. 41, 1891, p. 138.

CHEMICAL COMPOSITION OF MOLYBDIC OCHER.

INTRODUCTION.

All the textbooks on mineralogy give the composition of natural molybdic ocher as agreeing with that of the artificial product, molybdenum trioxide, MoO_3, which may be obtained by oxidizing the natural sulphide, molybdenite. As far as known but one analysis was ever made of the natural ocher, and though that suggested the desirability of further examination such has never been made. This is doubtless due to the fact that whereas the yellow molybdic ocher is very widespread in its occurrence, it seldom occurs in sufficient quantity and of such purity as to warrant any chemical investigation. The writer was fortunate enough to receive a sample of supposed autunite from the Foote Mineral Co., of Philadelphia, which on investigation was found to be molybdic ocher. As the mineral occurs in a pure state, some qualitative tests were made, and it was found that beside the molybdenum considerable ferric iron and water were present. The material was then examined under the microscope and found to be pure and especially free from limonite. Some artificial crystals of MoO_3 were prepared, and on comparing the two substances under the microscope such differences were found in their properties as to suggest that the mineral examined was not molybdite, but a new species—a hydrated ferric molybdate. The investigation thus opened was extended, and through the generosity of several people it has been possible to make analyses of natural molybdic ocher from five localities and to show that the natural ocher is not MoO_3, but $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$.

Hintze's summary of the literature on molybdite is so complete that only such points as bear directly on the question at hand will be mentioned here. Owen[1] described a deep yellow iron molybdate from Nevada City, Cal., and W. J. Taylor[2] described a similar mineral from Heard County, Ga., but neither article contained quantitative data of any value. Owen found 35 per cent of Fe_2O_3, but Genth[3] in a later publication made a determination on the same mineral and obtained 24.3 per cent Fe_2O_3. He says: "That which could be scratched off the quartz was not quite pure and contained a trace of limonite * * *. The sample examined gave 24.3 per cent of sesquioxide of iron, some of which was certainly mechanically mixed with it." Yet it would necessitate a mixture of nearly one-third limonite to give 24.3 per cent Fe_2O_3, while according to Genth the sample only "contained a trace of limonite." The analytical result was correct, but the interpretation wrong. The sample doubtless contained a trace of limonite, as the 24.3 per cent is slightly higher than the figure required for the formula $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$, which gives 22 per cent Fe_2O_3.

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[1] Proc. Acad. Nat. Sci. Philadelphia, vol. 6, 1852, p. 108.

[2] Am. Jour. Sci., 2d ser., vol. 19, 1855, p. 429.

[3] Idem, vol. 28, 1859, p. 248.

PHYSICAL PROPERTIES.

OPTICAL CHARACTERS.

The mineral has a fibrous structure and also forms radiating groups. Its color is yellow and many specimens have a silky luster. All of the fibers examined give parallel extinction. The double refraction is strong and the direction of elongation is always an axis of minimum elasticity. The color of the mineral in transmitted light is pale yellow. The pleochroism is strong but is masked by the very strong absorption. Normal to the elongation of the fibers the transmitted light is pale yellow; parallel to the elongation the color is a much stronger yellow. The absorption parallel to the elongation is so strong that thick fibers frequently appear almost black and opaque. This marked absorption is a very characteristic property of this mineral and can be used as a criterion for its determination. These same properties are mentioned by Lacroix[1] for molybdite from Corsica.

Crystals of MoO_3, prepared by roasting molybdenite in an open crucible, show very decided differences in their physical properties from those of the natural mineral. They are not fibrous, but platy and are colorless, nonpleochroic, and show no difference in absorption in different directions.

PYROGNOSTIC CHARACTERS.

On heating the mineral in a closed tube abundant water is easily given off and the mineral assumes a dark-olive color; on further heating it again becomes lighter in color. On heating the mineral in a crucible the color changes are very marked. At first the yellow mineral darkens and becomes a dark gray, appearing almost black and with slight olive tint, then it becomes a light yellow again, and on further heating changes to a deep-orange color. If the mineral now be allowed to cool the orange changes to yellow and back to orange again on reheating. If the dark-colored material be allowed to cool, it retains its dark-gray color and on reheating passes through yellow to the orange. On heating for some time at a higher temperature, the mineral, on cooling, becomes a permanent bright green. By further heating all of the molybdenum is volatilized and the dark-red ferric oxide remains. The mineral is readily soluble in hydrochloric acid, and is decomposed by ammonia, taking on a brown color (probably due to the separating ferric hydroxide). After a while, all the molybdenum of the mineral goes into solution, leaving the insoluble ferric hydroxide.

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[1] Lacroix, A., Minéralogie de la France, vol. 3, p. 8.

DENSITY.

The density of the powdered sample (No. 4, from Hortense, Colo.) was determined with a pycnometer, using 3 grams of material. The value obtained is 3.026. This is corrected on the basis of the following composition:

Mineral composition of sample of molybdite.

Molybdenite (density 4.7)	5.50
Silica (density 2.65)	16.51
Molybdite (density 2.99)	77.99
	100.00

The corrected value becomes 2.99 in which, however, no allowance is made for the extraneous moisture.

SOLUBILITY IN WATER.

An experiment was made to determine approximately the solubility of molybdite in water. About 3 grams of the mineral were stirred in a beaker for a day with 760 cubic centimeters distilled water at room temperature (about 25°), and then filtered repeatedly. The final filtrate showed a very faint cloudiness. It was evaporated down in platinum, the residue dissolved in HCl and the iron precipitated as hydroxide with ammonia and weighed. The 760 cubic centimeters of water contained 0.0051 grams of Fe_2O_3. On the assumption that this all came from the mineral, it is calculated that the solubility of molybdite in water is approximately 1 to 33,000 so that the mineral is rather insoluble.

CHEMICAL ANALYSES.

MOLYBDITE FROM NEW HAMPSHIRE.

The purest sample examined came from Westmoreland, N. H., and was very kindly furnished from the Brush collection of Yale University by Prof. Wm. E. Ford. Nearly a gram of material was obtained and this was divided into portions of a quarter gram weight. Macroscopically the specimen looked more earthy and not so finely crystallized as those obtained from other localities, but under the microscope it showed its characteristic optical properties, and was seen to be homogeneous, free from limonite, and to contain a small quantity of molybdenite scales. The first figure given for the water content, 16.98 per cent, was obtained by weighing the water direct, using the method of glass tubes as advocated by Penfield. The other two figures represent the loss up to 200°, at which temperature all the water of the mineral is given off. The residue was dissolved in HCl, and after filtering off the insoluble matter the iron was precipitated by ammonia, filtered off, dissolved in HCl, and reprecipitated and weighed, while hydrogen sulphide was passed into the combined ammoniacal filtrates until the characteristic red color was produced. The solution was then acidified with H_2SO_4 and after heating on the steam bath to allow the molybdenum sulphide to settle was filtered through a Gooch crucible. The sulphide was then dried, changed into the trioxide at a low heat, and weighed to constant weight. The filtrate from the molybdenum sulphide was made alkaline with ammonia, and hydrogen sulphide was again passed into the solution, which was then reacidified with H_2SO_4 and a small amount of molybdenum which had escaped precipitation in the first case was recovered. The filtrate on testing showed no more molybdenum, neither was any residue found on evaporating it to dryness. Tests showed the absence of calcium and magnesium. The weighed iron oxide was fused with sodium bisulphate, and determined volumetrically with a result that agreed with the gravimetric determination. The results obtained are as follows:

Analysis of molybdite from New Hampshire.

	1	2	3	Average.	Ratios.
H_2O	16.98	17.95	17.93	17.62	7.43=7½
Fe_2O_3	21.08	21.07	....	21.08	1.00=1
MoO_3	57.02	57.49	58.55	57.69	3.04=3
Insoluble	4.66	....	....	4.66	....
				101.05	

The average analysis with the insoluble matter deducted and reduced to 100 per cent, is compared below with the figures calculated for $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$.

Comparison of analysis with calculated values.

	Analysis.	Calculated.
H_2O	18.28	18.57
Fe_2O_3	21.87	22.01
MoO_3	59.85	59.42
	100.00	100.00

This formula has been verified by the analysis of molybdite from Arizona by Guild.[1] Two analyses made by him are quoted below.

Analyses of molybdite from Arizona (by Guild).

	1	2
Insoluble residue	4.86	2.66
Water	16.83	16.61
Ferric oxide, Fe_2O_3	20.88	21.18
Molybdic trioxide, MoO_3	57.38	59.79
Total	99.95	100.24

The average of these analyses with the insoluble residue deducted and recalculated gave the following values. The ratios lead to the formula $Fe_2O_3.3MoO_3.7H_2O$, which is half a molecule lower in water than the formula obtained by the writer.

Recalculated analysis of molybdite from Arizona.

	Analysis.	Ratios.
H_2O	17.355	7.06
Fe_2O_3	21.835	1.00
MoO_3	60.805	3.09

Partial water determinations were made on two samples of molybdite from New Hampshire, as follows, the amount of water being represented by the loss in weight, the crucible being heated at the temperature given till 6 hours additional heating produced no difference in weight.

Partial water determination.

	Per cent.
Total loss up to 110°	14.04
Total loss up to 125°	15.50
Total loss up to 185°	17.64
Total loss up to 200°	17.93

MOLYBDITE FROM OTHER LOCALITIES.

The quantity of material from other localities[2] was so small that exact values can not be expected, but the analyses all show a general agreement with the calculated values. The samples analyzed are as follows:

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[1] Guild, F. N., The composition of molybdite from Arizona: Am. Jour. Sci., 4th ser., vol. 23, 1907, p. 455.

[2] The characteristic optical properties of the ferric molybdite were also determined on specimens from Stanhope, N. J.; Gold Creek, Deer Lodge County, Mont.; Aldfield Township, Pontiac County, Quebec.

No. 1 is from Telluride, Colo., and is from the sample furnished by the Foote Mineral Co., Philadelphia.

No. 2 was very kindly furnished by Prof. A. J. Moses, of Columbia University, who states that the sample is probably from California, though the locality is not certainly known. Two samples were sent; one yellow, which was seen to be pure, and one brown, which was seen under the microscope to consist of a mixture of the pure yellow mineral and limonite. The appearance of this sample at once suggested that it was similar to one analyzed by Owen, which gave 35 per cent Fe_2O_3. It also showed the ease with which a mechanical mixture of molybdite and limonite could be detected under the microscope. The opaque brown limonite was scattered through some of the yellow molybdite and caused it to appear almost opaque, besides which there were numerous patches of earthy limonite. This sample was not analyzed.

No. 3 is from Renfrew, Ontario, and was very kindly furnished by Prof. C. Palache, of Harvard University. Most of the material is massive and appears earthy, though under the microscope it is seen to consist of minute fibrous crystals. The material did not look promising, but analysis showed values agreeing well with the others. Owing to an accident only the iron and molybdenum could be determined. These values are not given. On one of the specimens sent by Prof. Palache there was a small amount of the finely crystallized fibrous material which seemed to be very pure. This was scraped off and analyzed, and though only about 50 milligrams were available the results given under No. 3 were obtained.

No. 4 is from Hortense, Colo., and was received through the kindness of Mr. F. L. Hess. The yellow mineral occurs in lumps, several of which are over 2 centimeters in diameter. With the molybdite are associated molybdenite, quartz, and mica.. The sample looks earthy, but under the microscope it is seen to be well crystallized and shows the characteristic optical properties of molybdite as described earlier in this paper. A sample was selected as pure as could be obtained, but it was found on analysis to contain a large amount of insoluble matter. The powdered specimen caked together in the sample tube and probably contained some extraneous water. The analysis also showed too high a water content for molybdite.

The methods of analysis were the same as those employed with the New Hampshire material. By heating in a closed tube to obtain the water, some of the molybdenite which was mixed with the mineral doubtless was oxidized to the oxide, thus increasing the amount of molybdenum present. The results obtained are:

Analyses of molybdite.

	No. 1, Telluride, Colo.	No. 2, California.	No. 3, Renfrew, Ontario.	No. 4, Hortense, Colo.
H_2O	15.8	15.4	15.5	15.87
Fe_2O_3	19.0	15.8	17.3	15.95
MoO_3	59.3	47.7	55.7	46.77
Insoluble	[5.9]	24.0	9.4	22.01
	100.0	102.9	97.9	100.60

By deducting the insoluble matter and calculating the analyses to 100 per cent we obtain:

Analyses of molybdite with insoluble matter deducted and percentages recalculated.

	1	2	3	4	Calculated.
H_2O	16.8	19.5	17.3	20.19	18.57
Fe_2O_3	20.2	20.0	16.6	20.30	22.01
MoO_3	63.0	60.5	62.9	59.42	59.42
	100.0	100.0	100.0	100.00	100.00

The ratios of the above analyses are as follows:

Ratios of analyses of molybdite.

	Fe_2O_3.	H_2O.	MoO_3.
No. 1	1.0	7.3	3.4
No. 2	1.0	8.6	3.3
No. 3	1.0	7.8	3.5
No. 4	1.0	8.8	3.3

The analyses agree sufficiently well to show that the mineral is uniform in composition and the analyses of the material from New Hampshire serve to establish its formula.

The insoluble residue in No. 4, consisting of 5.5 per cent MoS_2 and 16.5 per cent SiO_2, was roasted in an open crucible to change the MoS_2 into MoO_3 and then weighed. The oxide of molybdenum was then dissolved by HCl, leaving the silica, which was tested with HF for its purity. The determination of water was made in two ways—by loss in weight and by direct weighing. It was found that the water given off at 110° by heating the mineral in a glass tube in a toluene bath while a current of dry air was passed over the mineral and collecting and weighing the water (A, below) was considerably greater than the amount given off at 110° by heating the mineral in a crucible in a toluene bath, determining the water by the loss in weight (B, below). The results are shown below:

Water content of molybdite.

	A	B
Amount given off at 110°	13.77	11.39
Amount given off at 200°	2.23	4.34
	16.00	15.73

In considering the mode of formation of the hydrous ferric molybdate (molybdite) it may be well to call attention to the fact that the interaction of molybdic acid, $H_2MoO_4.H_2O$, on limonite may be written so as to yield a product with a formula that is identical with the new formula and which balances the equation:

$$2Fe_2O_3.3H_2O + 6(H_2MoO_4.H_2O) = 2(Fe_2O_3.3MoO_3.7\tfrac{1}{2}H_2O).$$

ARTIFICIAL MOLYBDITE.

Chemical dictionaries mention but two hydrous ferric molybdates, neither of which is crystalline, and which approximate in formula to $Fe_2O_3.4MoO_3.7H_2O$ and $Fe_2O_3.5MoO_3.16H_2O$. On adding a solution of ammonium molybdate to an excess of a solution of a ferric salt no precipitate is formed, but on reversing the process and adding the ferric salt to the ammonium molybdate a voluminous yellow precipitate appears. A precipitate thus prepared was air-dried for about a week and analyzed with the following results:

Analysis and ratios of artificial ferric molybdate.

	Analysis.	Ratios.
Fe_2O_3	15.9	1.0
MoO_3	61.6	4.3
H_2O (by difference)	22.5	12.5
	100.0	

These results are between those of the two salts above quoted. It was found, however, that a large amount of free molybdic acid contaminated the material, and the impossibility of air-drying the noncrystalline mass sufficiently accounts for the high water content. It is therefore believed that neither of the two salts above mentioned and described in chemical dictionaries has any existence, but that they are mixtures of a salt of the formula $Fe_2O_3.3MoO_3+nH_2O$ with molybdic acid and water.

A preliminary experiment of heating precipitated ferric hydroxide and molybdic acid in the correct molecular proportions with an excess of water in a glass bomb failed to give any result. After heating to about 150° for several hours there was no indication of any reaction, and on higher heating the bomb exploded.

An attempt was next made to crystallize the yellow amorphous precipitate. The precipitate was heated with water in a glass bomb up to 180° to 200° for several days, and when examined was found to consist of a mass of fine yellow crystals and a greenish, amorphous mass. On shaking up the tube the green part settled very quickly and the minute yellow crystals settled so slowly that a nearly perfect separation of the two products could be made. The yellow crystalline part was examined under the microscope and found to consist of three products, all crystallized. The most abundant salt occurs in minute, pale-yellow tablets of quadratic outline. Some of them which seem to be isotropic have an octagonal shape suggesting combinations of the cube and octahedron. They were too small to test for interference figures. The second most abundant salt occurs in pale-yellow, fibrous prisms and also in radiated, fan-shaped masses which show the characteristic absorption of the natural mineral and are probably identical with it. The third salt also occurs in prisms, which, however, are not fibrous, do not show any absorption, and seem to be colorless. They may be molybdic acid, but the first two salts are probably hydrated ferric molybdates.

OCCURRENCE OF NATURAL TRIOXIDE OF MOLYBDENUM.

The existence of the trioxide of molybdenum (MoO_3) as a natural mineral has not been demonstrated,[1] and what is commonly believed to be MoO_3 is shown to be a hydrated ferric molybdate, $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$. This composition for molybdite has been verified in the analysis by Guild. The occurrence in Texas of what has been supposed to be MoO_3, and which has been so described, has been shown to be powellite, and the Russian specimen supposed to be MoO_3 is also doubtless powellite. Until it is shown conclusively that an oxide of molybdenum does exist in nature, the name molybdite must be retained for the hydrated ferric molybdate.

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[1] Lacroix found the molybdite from Corsica to contain iron and water. Minéralogie de la France, vol. 4, p. 296, 1910.

ANALYSIS OF TOURMALINE FROM ELBA.

While the writer was analyzing a number of tourmalines from San Diego County, Cal., Prof. Clarke suggested that it would be advisable to analyze the pale-pink variety of tourmaline from the Island of Elba. Rammelberg's analysis of tourmaline from this locality indicated that this tourmaline was probably near in composition to one of the end products of the isomorphous mixtures which form the mineral tourmaline. A number of these crystals were purchased from the Foote Mineral Co., who wrote in regard to them: "All of these were secured in exchange from the late Prof. Bombicci, who collected them in Elba many years ago." The crystals were picked over and crushed to small fragments, after which each piece was examined under a hand lens and only the transparent pure material was selected. These were then washed with cold dilute HF to remove any albite, mica, etc., that might be adhering to the tourmaline. The sample finally powdered and analyzed was pure. The density of the mineral (determined by Thoulet solution) is 3.04–3.05, as the mineral sank at 3.043 and floated at 3.050. The analysis is as follows:

Analysis and ratios of tourmaline from Elba.

	Analysis.	Ratios.	
SiO_2	37.89	0.632 = 4.00	
B_2O_3	10.28	.147 = 0.93	
Al_2O_3	43.85	2.580	
Ti_2O_3	.04	.002	
FeO	.11	.003	
MnO	.11	.003	
CaO	.07	.003	=20.08[a]
Na_2O	2.43	.079	
Li_2O	1.66	.111	
H_2O	3.47	.386	
F	.10	.005	
MgO, K_2O	None.		
	100.01		
−O=F=	.04		
	99.97		

[a] These ratios give the hydrogen atoms equivalent to the metals.

The ratios agree very well with those proposed by Penfield, namely, 4:1:20. A discussion of the results will be given in a later paper on the California tourmalines, as at present it is only desired to place the above analysis on record. The state of oxidation of the titanium, iron, and manganese are given arbitrarily.

EVANSITE FROM TWO AMERICAN LOCALITIES.

EVANSITE FROM IDAHO.

Some specimens of evansite, reported as being found in the immediate vicinity of Goldburg, Idaho, were received through the courtesy of Mr. C. R. Potts, of that place. The massive amorphous mineral occurs in seams and is very brittle with a conchoidal fracture. Its hardness is about 3, and its color is generally brown, though it varies considerably. Some specimens are yellow, or white, or dark red. The brown specimens very much resemble common brown opal.

An analysis of the brown material gave the following results:

Analysis and loss of water of evansite from Idaho.

Analysis.		Loss of water.	
H_2O	36.96		
P_2O_5	19.14	At 107°	20.00
Fe_2O_3	5.49	175°	7.36
Al_2O_3	34.48	255°	3.13
CaO	4.32	290°	.94
MgO	Trace.	To low redness	3.90
FeO	None.	Blasting	1.61
	100.39		36.94

A determination (by means of Thoulet solution) of the relation of the density to the amount of iron present gave the following values:

Relation of density to iron content.

Color of mineral.	Fe_2O_3.	Average density.	Limits.
	Per cent.		
Dark red	6.60	2.00	1.990–2.016
Brown	5.49	1.98	1.972–1.990
Yellow	2.15	1.94	1.927–1.947

By plotting these values it is found that the density of the mineral free from iron should be between 1.88 and 1.91, though this value does not necessarily represent that of pure evansite, as the material on which these determinations were made contains appreciable calcium. Forbes[1] gives the following determinations of the density:

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[1] See literature at end of paper for reference.

Densities of evansite.

Colorless, translucent	1.822
Colorless	1.872
Faint yellow	2.099
Semiopaque	1.965

The average of these densities is 1.939, though possibly the lowest figure more nearly represents the density of the pure mineral. Smith gives the value 1.842 as the density of colorless to milky white, translucent material.[1] Kovar gives for white 1.874 (0.87 per cent Fe_2O_3), and for yellow 1.937 (1.92 per cent Fe_2O_3). These values give an average for all the determinations of 1.93, and an average of the lowest values, representing possibly the purer mineral, gives 1.86.

A determination by F. E. Wright of the index of refraction of the colorless evansite from Idaho gave 1.485, the index for the colored varieties not varying more than 0.01 from this value.

EVANSITE FROM ALABAMA.

The second sample was received through Prof. Clarke from Mr. Charles Catlett, and the locality is given as "from the coal seam just west of Columbiana, Ala." It is associated with coal, shows a light-yellow color with a resinous luster, and is transparent in small pieces. It is very brittle. An approximate analysis serves to identify the mineral, the phosphoric acid being determined by difference.

Analysis of evansite from Alabama.

Al_2O_3	38.33
CaO	1.03
MgO	.75
Loss on ignition	38.19
P_2O_5 (by difference)	21.70
	100.00

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[1] Wrongly given as 1.939 in Dana's App. II, p. 25.

[2] These references only mention the occurrence of evansite.

MANGANOTANTALITE FROM MOUNT APATITE, MAINE.

The crystals here described were received from Prof. Palache, who suggested that they were manganotantalite. They are associated with the minerals characteristic of these lithium-bearing pegmatites, as albite, lepidolite, etc. Most of the crystals are small, several millimeters in length, and are tabular to the *a* face (Dana's orientation). The specific gravity was determined as 7.14, showing that in these crystals the tantalic acid largely predominates over the columbic acid. A partial analysis showed further that iron was almost entirely absent, so that the crystals may well be termed manganotantalite. The analysis gave the following results:

Analysis of manganotantalite from Mount Apatite, Maine.

Ta_2O_5 Cb_2O_5	85.35
FeO	.16
MnO (by difference)	14.49
	100.00

The forms present are: *b*{010}, *a*{100}, *c*{001}, *m*{110}, *g*{130}, *j*{320}, *z*{530}, *d*{730}, *k*{103}, *u*{133}, *n*{163}. The angles measured are shown below. Most of the faces were dull and gave poor reflections.

Forms and angles for manganotantalite.

Symbol.	Measured.		Calculated.	
	°	′	°	′
$b\wedge m = (010) : (110)$	50	28	50	22
$b\wedge g = (010) : (130)$	21	27	21	55
$b\wedge z = (010) : (530)$	63	10	63	34
$b\wedge d = (010) : (730)$	70 70	15 06	70	27
$c\wedge k = (001) : (103)$	19	38	19	42
$b\wedge n = (010) : (163)$	[a] 30		30	50
$n\wedge n''' = (163) : (1\bar{6}3)$	[a] 118		118	20
$n\wedge n' = (163) : (\bar{1}63)$	[a] 22		19	54
$b\wedge u = (010) : (133)$	50	45	50	03
$u\wedge u''' = (133) : (1\bar{3}3)$	81	15	79	54
$u\wedge u' = (133) : (\bar{1}33)$	30	04	29	57

[a] Approximate.

Measurements for the prism *j* {320} are as follows:

Measurements of j {320}.

Crystal No.—	Size of face.	Reflection.	Symbol.	Measured.		Calculated.	
				°	′	°	′
1	Narrow	*p*.	$110\wedge320$	9	39	10	44
2	Broad	*p*.	$010\wedge320$	61	21	61	06
2	Broad	*g*.	$320\wedge3\bar{2}0$	57	12	57	48
3	Broad	*f*.	$010\wedge320$	61	12	61	06
4	Broad	*g*.	$010\wedge320$	61	13	61	06

The faces of (133), (100) are large, those of (163), (103), (110), (320) are small, and most of the others are very narrow faces.

ZINNWALDITE FROM ALASKA.

The occurrence of zinnwaldite with cassiterite and topaz in the York region, Alaska, has already been mentioned[1] and the results of a quantitative analysis of this mica are here presented. The axial angle, 2E, for sodium light, was measured 49° 29′. The sample analyzed was probably fairly pure.

Analysis of zinnwaldite from Alaska.

	Analysis.	Ratios.	
SiO_2	46.80	.775	775
Al_2O_3	24.50	.240	243
Fe_2O_3	.50	.003	
FeO	6.35	.088	111
MnO	1.38	.019	
CaO	.24	.004	
Na_2O	1.73	.033	131
K_2O	9.20	.098	
Li_2O	3.73	.124	124
H_2O	.88	.098	552
F	8.63	.454	
	103.94		
−O=2F	3.63		
	100.31		

In the ratios, the soda and potash are taken together and the small amount of water present is considered as hydroxyl and added to the fluorine ratio. The empirical formula gives:

$$Si_{775}Al_{486}Fe_{111}K_{262}Li_{248}F_{552}O_{2369}$$

The total oxygen is very slightly greater than three times the silica, the ratio O: Si being 3.06 : 1. The mineral is therefore considered as a metasilicate and the formula may be written

$$(SiO_3)_{775}(AlF_2)_{276}K_{262}Li_{248}Fe_{111}(AlO)_{44}Al_{166}$$

or

$$(SiO_3)_{12}(AlF_2)'_{4.27}K'_{4.06}Li'_{3.84}Fe''_{1.72}(AlO)'_{.68}Al'''_{2.57}$$

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[1] Bull. U. S. Geol. Survey No. 262, 1905, p. 129.

SOME NEW FORMS OF CALCITE CRYSTALS.

CALCITE FROM ANDREASBERG, GERMANY.

Several specimens of calcite labelled "Andreasberg, Harz Mountains," were purchased from a local mineral dealer. One specimen shows large tabular crystals with only the base $c\{0001\}$ and prism $m\{10\bar{1}0\}$. Other specimens consist of groupings of tabular crystals which are somewhat unusual in their combinations. These tabular calcites are arranged in superimposed parallel or nearly parallel groupings forming vertical columns several centimeters long, the individual crystals being up to 13 millimeters wide and 5 millimeters high. The dominant forms on these crystals are the base $c\{0001\}$ and prism $m\{10\bar{1}0\}$, but characteristically all of them also show the new prism $\mathfrak{j}\{7.6.\overline{13}.0\}$ as narrow rounded faces. Very narrow faces of $s\{05\bar{5}1\}$ and minute faces of $v\{21\bar{3}1\}$ are present in numerous specimens. Some of these crystals, which seem to be single, show an easy parting parallel to the base and may be built up of many thinner tabular crystals in parallel position. Associated with these calcites are numerous fourlings of harmotome.

Measurements of the ϕ angle for $s\{05\bar{5}1\}$ varied from 78° 38′ to 78° 47′; calculated, 78° 32′.

The dihexagonal prism faces are bright, but rounded, so that no accurate measurements could be made. They gave, however, a bright signal in the mass of reflections caused by the rounded surfaces and the measurements given below were of this bright signal. The faces were seen to be in the prism zone mm' and therefore could not be scalenohedrons with complex indices.

Measurements of $\mathfrak{j}\{7.6.\overline{13}.0\}$.

	ϕ	
	°	′
Measured	27	34
Do	27	20
Do	27	32
Do	27	37
Average	27	31
Calculated	27	27

This prism face is present on all of the crystals, but on few of them is suitable for measurement. The results given were all obtained from one crystal. It seems strange that this form has not been described before—at least the writer could find no mention of it in the literature—as the specimens are supposed to have come from a locality well known for its calcites.

It hardly seems correct to regard these prism faces as corrosion forms or other secondary formation. Though the base and prism faces on these calcites are dull they do not show any definite signs of etching and though the new prism faces are rounded they are considered as belonging to a well-established form for calcite. As stated, the form occurs on all of the crystals and all 12 of the faces are present on each crystal. These crystals are shown in figure 8.

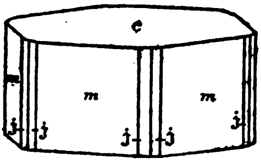

FIGURE 8.—Calcite from Germany.

CALCITE FROM ENGLAND.

The crystals here described are from a group containing individual crystals the largest of which measures 4 by 2 centimeters. The exact locality is not known. The crystals have a trigonal habit due to the predominance of a steep negative rhombohedron. The forms present on these crystals are: $r\{10\bar{1}1\}$, $M\{40\bar{4}1\}$, $\eta\{50\bar{5}1\}$, $Y\{60\bar{6}1\}$, $o\{11.0.\overline{11}.2\}$, $e\{01\bar{1}2\}$, $f\{02\bar{2}1\}$, $d\{08\bar{8}1\}$, $C\{0.13.\overline{13}.1\}$, $n\{41\bar{5}3\}$, $G\{72\bar{9}5\}$, $w\{31\bar{4}5\}$, $v\{21\bar{3}1\}$, $\gamma\{53\bar{8}2\}$, $y\{32\bar{5}1\}$, and a new form $\mathfrak{p}\{4.20.\overline{24}.7\}$. The following table gives the average of the measured angles compared with the calculated values:

Forms and angles of calcite from England.

Letter.	Symbol.	Number measured.	Measured.		Calculated.	
			ϕ	ρ	ϕ	ρ
			° ′	° ′	° ′	° ′
M	$40\bar{4}1$	3	0 02	75 48	0 00	75 47
η	$50\bar{5}1$	2	0 02	78 11	0 00	78 32
o	$11.0.\overline{11}.2$	1	0 12	79 35	0 00	79 33
y	$60\bar{6}1$	2	0 02	80 11	0 00	80 24
e	$01\bar{1}2$	2	0 00	26 15	0 00	26 15
f	$02\bar{2}1$	5	0 00	63 07	0 00	63 07
d	$08\bar{8}1$	4	0 00	83 01	0 00	82 46
C	$0.13.\overline{13}.1$	1	0 12	85 30	0 00	85 32
n	$41\bar{5}3$	1	10 55	56 22	10 54	56 26
G	$72\bar{9}5$	3	12 22	58 22	12 13	58 14
w	$31\bar{4}5$	2	14 25	35 05	13 54	35 25
v	$21\bar{3}1$	2	19 07	69 10	19 07	69 02
γ	$53\bar{8}2$	8	21 43	74 28	21 47	73 51
y	$32\bar{5}1$	2	23 21	77 02	23 25	76 54
$\mathfrak{p}$	$4.20.\overline{24}.7$	13	8 56	72 09	8 57	72 20

The indices of the form above referred to as ꝑ $\{4.20.\overline{24}.7\}$ could not be definitely determined. Many faces of this form are present on these crystals; in fact the form is characteristic for this group, as it is present on all the crystals. But it is always rounded and uneven, and will give when mounted on the goniometer either a group of reflections or else two or three distinct signals. The various measurements for this form are as follows:

Measurements of ꝑ $\{4.20.\overline{24}.7\}$.

Crystal No.	Size of face.	Number of signals.	Reflection.	ϕ		ρ		Signal.
				°	′	°	′	
1	Minute...	2	*p.*	8	17	72	08	Distinct.
			p.	8	20	71	36	Very faint.
1	Small...	3	*f.*	8	23	71	40	Distinct.
			p.	8	20	72	08	Very faint.
			p.	8	23	71	15	Do.
1	...do.....	3	*f.*	8	48	71	59	Distinct.
			p.	8	26	71	31	Very faint.
			p.	9	01	72	19	Do.
1	...do.....	3	*p.*	8	23	71	40	Distinct.
			p.	8	46	71	05	Do.
			p.	9	06	72	19	Do.
2	Minute...	1	*p.*	8	54	72	15	Very faint.
2	Small...	3	*f.*	9	13	72	17	Distinct.
			p.	8	52	71	58	Very faint.
			p.	8	15	71	30	Do.
2	...do.....	....	*f.*	9	56	72	20	Many.
2	...do.....	3	*f.*	10	19	73	23	Very faint.
			p.	9	24	72	04	Do.
			p.	10	17	73	43	Do.
2	Minute...	2	*f.*	9	16	72	41	Distinct.
			p.	8	37	71	48	Very distinct.
3	Small...	2	*p.*	8	44	71	56	Distinct.
			p.	9	23	72	38	Do.
			p.	9	07	72	38	Do.
3	...do.....	2	*p.*	8	34	71	58	Do.
3	Minute...	1	*p.*	9	15	72	36	One distinct.
3	Small...	1	*p.*	8	48	72	51	Distinct.

Average of measurements of 13 faces: $\phi=8°\ 56'$, $\rho=72°\ 09'$. Calculated, $\phi=8°\ 57'$, $\rho=72°\ 20'$.

An average of the values with "signal distinct" is $\phi=8°\ 45'$, $\rho=72°\ 11'$, or nearly the same.

Although these measurements are near to the angular values of the simple form $\{15\bar{6}2\}$, which are $\phi=8°\ 57'$, $\rho=70°\ 00'$, the ρ angle is sufficiently different to preclude their reference to this form. If we take the average measured value, $\phi=8°\ 56'$, $\rho=72°\ 09'$, we find that the ratio $h:k=1:5$ (ϕ calculated $=8° 57'$), and the ratio $i:l=3.392$, which gives as the indices $1.5.\bar{6}.\frac{7}{4}$ or $4.20.\overline{24}.7$, which are not especially complex and the calculated angles for which are $\phi=8° 57'$, $\rho=72° 20'$, agreeing fairly well with the average of the measurements given above. The above detailed description is given in order to call attention to these trigonal calcites in the hope that some one may find a similar group having this new form which will admit of an accurate measurement whereby the symbol of the form may be definitely determined.

A single minute face of $C\{0.13.\overline{13}.1\}$ was noted and this was poorly developed, giving a poor reflection. Sansoni[1] gives this form as new and it is also described by Höfer[2] as new, being determined by zonal relations, but it is considered as doubtful by Goldschmidt,[3] he suggesting that the correct symbol may be $\{0.14.\overline{14}.1\}$, though Sansoni's measurements, like the writer's above, agree well for $\{0.13.\overline{13}.1\}$. Figure 9 shows one of the smaller crystals of this group with the important forms developed at one corner. As shown in this figure, the combinations vary at similar crystallographical places, being much simpler at some corners than at others. Though all the intersection lines are here drawn straight, many of them are considerably curved on the crystals, especially on the larger ones, which moreover show a much simpler combination than the smaller ones. Figure 10 shows the appearance of the larger crystals.

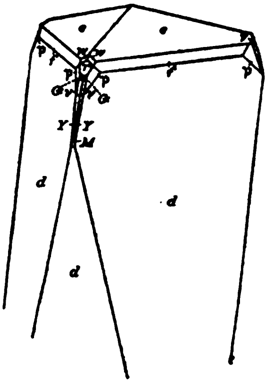

FIGURE 9.—Calcite from England.

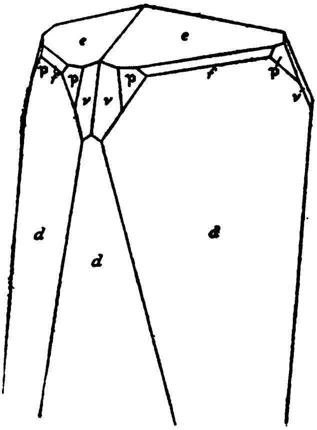

FIGURE 10.—Calcite from England.

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[1] Zeitschr. Kryst. Min., vol. 10, 1885, p. 564.

[2] Min. pet. Mitt., vol. 12, 1891, p. 487 (Ref. Zeitschr. Kryst., vol. 24, p. 431).

[3] Index der Krystallformen der Mineralien, vol. 1, 1886, p. 388.

CALCITE FROM SAN FRANCISCO, CAL.

The crystals here described were collected by the writer some years ago. They occurred in cavities in what seems to be an altered rock near Fort Point, San Francisco. They were found in the same locality which has furnished pectolite and datolite[1] as well as apophyllite and gyrolite,[2] though the crystals here described were not found directly associated with any mineral other than quartz. The crystals are of the common scalenohedral (*v*) habit of calcite with *e* and *r* as termination, and often reach a size of several centimeters. They differ somewhat from the ordinary calcite crystals in that the form $\gamma\{53\bar{8}2\}$ is almost always present as a very narrow face below *v* and minute faces of $N\{4.16.\overline{20}.3\}$ are also almost always present. One single crystal, colorless and transparent and about 4 millimeters in diameter, showed some differences from the other crystals and was therefore measured. The essential difference was that the *e* faces were replaced by two faces of $y{:}\{23\bar{5}8\}$, the *e* faces being entirely absent. In addition a new form in the zone *re* was noted. The forms present on this crystal are: $r\{10\bar{1}1\}$, $v\{21\bar{3}1\}$, $\gamma\{53\bar{8}2\}$, $y{:}\{23\bar{5}8\}$, $N\{4.16.\overline{20}.3\}$, and the new form $\mathfrak{k}\{1.6.\bar{7}.13\}$. The average measured angles are compared with the calculated ones in the following table:

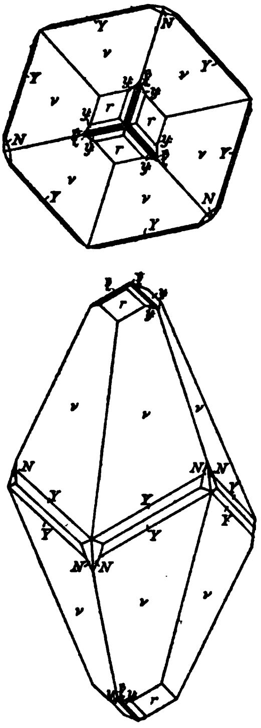

FIGURE 11.—Calcite from California.

Forms and angles of calcite from San Francisco, Cal.

Letter.	Symbol.	Number measured.	Measured.		Calculated.	
			ϕ	ρ	ϕ	ρ
			° ′	° ′	° ′	° ′
v	$21\bar{3}1$	2	19 04	69 04	19 07	69 02
γ	$53\bar{8}2$	2	21 42	74 13	21 47	73 51
y:	$23\bar{5}8$	6	23 22	28 19	23 25	28 15
N	$4.16.\overline{20}.3$	4	10 55	80 32	10 54	80 35
𝔨	$1.6.\bar{7}.13$	3	7 31	26 27	7 35	26 27

Only three faces of the new form are present. They are all narrow and bright, but striated like almost all the faces in this zone. This striation caused the reflections, particularly the first one, to broaden out so that accurate measurement was not possible. The three measurements are:

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[1] Bull. Dept. Geol., Univ. Cal., 2, No. 10, 1901.

[2] Bull. U. S. Geol. Survey No. 262, 1905, p. 124.

Angle values for **k**$\{1.6.\bar{7}.13\}$.

	ϕ	ρ
	° ′	° ′
Calculated	7 35	26 27
Measured:		
(1)	7 57	26 34
(2)	7 04	26 24
(3)	7 01	26 24

The form is considered to be well established. It is shown in figure 11, which illustrates the ideal combination found on the crystal measured.

CALCITE FROM HILLSBORO, N. MEX.

These crystals were received from Mr. C. H. Gordon, the locality being Macey's mine, 2½ miles east of Hillsboro, N. Mex. They are loose crystals, a centimeter thick and somewhat longer, and are associated with large endlichite crystals. Many of the calcite crystals have partially adhering white or pink gangue. Almost all the crystals, generally doubly terminated, show only the prism *m*$\{10\bar{1}0\}$ and the negative rhombohedron *e*$\{01\bar{1}2\}$. The *e* faces are striated parallel to their intersection with *r*, and the prism faces are covered with triangular markings or etch figures. These triangular markings always point toward the *e* face, the base of the triangle being nearest the *r* face.

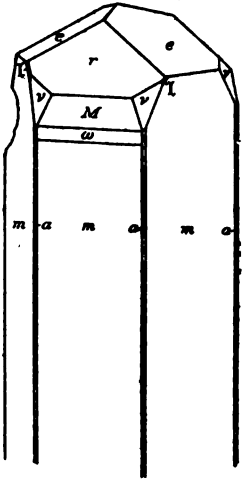

FIGURE 12.—Calcite from New Mexico.

Two crystals showed considerable differences from the others and were therefore measured, the results being given below. Crystal No. 1 is prismatic, 12 millimeters long and 4 millimeters thick, colorless, and transparent. It is shown in figure 12, which represents the crystal as it actually is, except that the narrow scalenohedra in the zone *r e* are not shown. The forms present on this crystal are: *m*$\{10\bar{1}0\}$, *a*$\{11\bar{2}0\}$, *r*$\{10\bar{1}1\}$, *M*$\{40\bar{4}1\}$, *ω*$\{28.0.\overline{28}.1\}$, *e*$\{01\bar{1}2\}$, *w*$\{31\bar{4}5\}$, *G*$\{52\bar{7}9\}$, *t*$\{21\bar{3}4\}$, *v*$\{21\bar{3}1\}$, and the new form **l**$\{3.10.\overline{13}.3\}$.

Forms and angles of calcite from New Mexico.

Letter.	Symbol.	Number measured.	Measured.		Calculated.	
			ϕ	ρ	ϕ	ρ
			° ′	° ′	° ′	° ′
r	$10\bar{1}1$	3	0 01	44 36	0 00	44 36
M	$40\bar{4}1$	3	0 01	75 44	0 00	75 47
ω	$28.0.\overline{28}.1$	3	0 01	87 48	0 00	87 55
e	$01\bar{1}2$	1	0 05	26 16	0 00	26 15
w	$31\bar{4}5$	1	14 08	35 20	13 54	35 25
G	$52\bar{7}9$	2	15 56	34 27	16 06	34 23
t	$21\bar{3}4$	1	19 55	32 57	19 07	33 07
v	$21\bar{3}1$	4	19 06	69 07	19 07	69 02
𝔩	$3.10.\overline{13}.3$	2	12 56	75 33	12 44	75 31

For the new form 𝔩$\{3.10.\overline{13}.3\}$ only two faces are present, both of which gave poor reflections, one much poorer than the other. The one giving a poor but distinct signal, measured $\phi = 12° 54'$ (calculated, $12° 44'$); $\rho = 75° 36'$ (calculated, $75° 31'$).

The limits of repeated measurements of these two faces gave:

Angle values for 𝔩 $\{3.10.\overline{13}.3\}$.

	ϕ	ρ
	° ′ ° ′	° ′ ° ′
Calculated.........	12 44	75 81
Measured:		
(1).............	12 42 to 13 03	75 30 to 75 36
(2).............	12 24 to 13 17	75 29 to 75 36
Average......	12° 56′	75° 33′

The form was seen to lie in the zone *r m*, and measurement of the angle $(10\bar{1}1) : (\overline{13}.10.3.3)$ gave $50° 35'$ (calculated, $50° 16'$). The form, considered as well established, is shown in figure 12.

Crystal No. 2 is incomplete and as now formed nearly equidimensional, measuring a centimeter in diameter. It is colorless and though in part transparent is cloudy and translucent in other places. The forms present on this crystal are: $m\{10\bar{1}0\}$, $r\{10\bar{1}1\}$, $e\{01\bar{1}2\}$, $f\{02\bar{2}1\}$, and the three new forms $o\{0.14.\overline{14}.17\}$, $O\{8.2.\overline{10}.3\}$, 𝔮$\{2.16.\overline{18}.1\}$ of which the latter is doubtful. The angular values are given in the table following.

Forms and angles of calcite from New Mexico.

Letter.	Symbol.	Number measured.	Measured.		Calculated.	
			ϕ	ρ	ϕ	ρ
			° ′	° ′	° ′	° ′
r	$10\bar{1}1$	1	0 29	44 56	0 00	44 36
e	$01\bar{1}2$	3	0 00	26 15	0 00	26 15
f	$02\bar{2}1$	2	0 00	63 33	0 00	63 07
o	$0.14.\bar{14}.17$	3	0 00	39 02	0 00	39 05
O	$8.2.\bar{10}.3$	2	10 29	70 58	10 54	71 38
q	$2.16.\bar{18}.1$	4	5 43	86 33	5 49	86 36

The large faces of $O\{8.2.\bar{10}.3\}$ are dull and give no distinct signal, only a blaze of light. Two faces were measured with the following result:

Angle values for $O\{8.2.\bar{10}.3\}$.

	ϕ	ρ
	° ′	° ′
Calculated	10 54	71 38
Measured:		
(1)	10 21	71 07
(2)	10 36	70 48

Although the faces are dull and give no distinct reflections the measurements serve to fix the indices, and as the form occurs in large plane faces it is considered as well established. The corresponding negative scalenohedron $B\{2.8.\bar{10}.3\}$ has been noted a number of times.

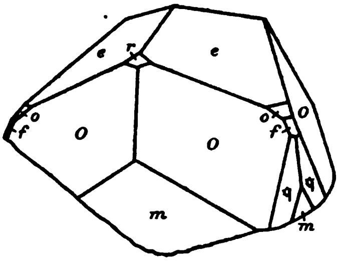

FIGURE 13.—Calcite from New Mexico.

Measurements for the form $o\{0.14.\bar{14}.17\}$ are as follows, the faces being bright and giving fairly good reflections:

The angles between the three faces of this form and *e* were measured.

$\{0.14.\bar{14}.17\} : \{01\bar{1}2\}=12°\ 52'$ to $12°\ 53'$; therefore $\rho=39°\ 07'$ to $39°\ 08'$.
$\{0.14.\bar{14}.17\} : \{01\bar{1}2\}=12°\ 44'$ to $12°\ 45'$; therefore $\rho=38°\ 59'$ to $39°\ 00'$.
$\{0.14.\bar{14}.17\} : \{01\bar{1}2\}=12°\ 43'$ to $12°\ 44'$; therefore $\rho=38°\ 58'$ to $38°\ 59'$.

Average $(\rho)=39°\ 02'$.
Limits, $38°\ 58'$ to $39°\ 08'$.

The only form for which the angle agrees is the complex one $\{0.14.\overline{14}.17\}$. Two simple forms which approximate to $\{0.14.\overline{14}.17\}$ are given in the table below, but, as can be seen, neither is sufficiently close to the measured values.

Calculated for $\{05\overline{5}6\}$, $\rho=39° 25'$.
Calculated for $\{0.9.\overline{9}.11\}$, $\rho=38° 54'$.

Four faces of the form 𝔮 $\{2.16.\overline{18}.1\}$ are present, the remainder of the crystal having cleaved off. Though all the faces are bright, they are very rounded, and in some cases form with *m* $\{10\overline{1}0\}$ a rounded surface. They gave, however, a bright signal in the midst of the mass of signals caused by the rounded surfaces, and it is these single bright signals that were measured.

Angle values for 𝔮$\{2.16.\overline{18}.1\}$.

	ϕ		ρ	
	°	'	°	'
Calculated	5	49	86	36
Measured	5	48	86	39
Do	5	31	86	27
Do	5	54	86	33
Do	5	37	86	33
Average	5	43	86	33

Measurements of the prism face (in zone *cem*) gave $\rho=89° 58'$ instead of 90° 00'. While the above measurements agree very well with the calculated angles, the form can not be considered as determined, for it is too rounded. It must be classed as a doubtful form. The forms are shown in figure 13, an attempt to show the crystal as it actually is.

CALCITE FROM LINCOLN, R. I.

The crystals here described were received from Mr. A. L. Stevens, of Providence, R. I., and the locality is given as Dexter lime quarry, Lincoln, R. I. For the kindness of Mr. Stevens in sending the specimens the writer's thanks are due. The crystals are on limestone and are associated with a pearly mineral forming almost colorless spherulites which have become brown on the surface. Other specimens show "nacrite" a talcose or micaceous mineral, quartz in flattened crystals, and curved rhombohedra of dolomite.

The calcite is found in three types of crystals: (1) Simple rhombohedra $r\{10\overline{1}1\}$, abundant; (2) crystals apparently prismatic, and more fully described below; (3) scalenohedral crystals showing large faces of $v\{21\bar{3}1\}$, but the crystals were so rounded that no measurements were made of them. Those of the second type are found on the rhombohedra of the first type and are not over several millimeters long, and the simple rhombohedra are seldom over a millimeter thick. Though the rhombohedral crystals are generally smooth and bright, those of the second type are very much etched and rounded, making it difficult to obtain satisfactory readings. The crystals have a prismatic appearance due to the presence of the negative rhombohedron $\Gamma\{0.17.\overline{17}.1\}$, and a form vicinal to $a\{11\bar{2}0\}$, and having the approximate symbol $\mathfrak{t}\{17.16.\overline{33}.1\}$. No prism faces were noted on the single crystal measured. The forms present are: $e\{01\bar{1}2\}$, $\varepsilon\{01\bar{1}1\}$, $\Gamma\{0.17.\overline{17}.1\}$, S:$\{11.8.\overline{19}.3\}$(?) $\mathfrak{t}\{17.16.\overline{33}.1\}$(?). The faces of most of these forms were so poor that the correct symbols could not be definitely determined. Figure 14 shows the general appearance of the crystal except that while the intersection of two faces is here shown as a straight line on the crystal they are frequently curved and rounded. The crystal was set in polar position by means of the e faces, and the other forms gave the following measurements:

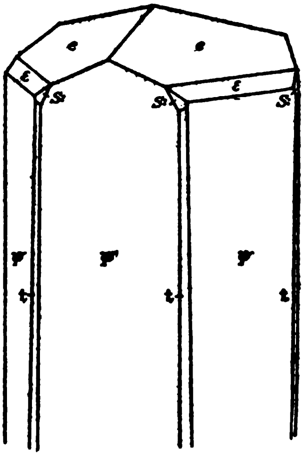

FIGURE 14.—Calcite from Rhode Island.

$\varepsilon\{01\bar{1}1\}$: ρ calculated = 44° 36′; ρ measured = 47° 53′, 45° 45′, 42° to 45°. All faces gave a mass of signals.

$\Gamma\{0.17.\overline{17}.1\}$: ρ calculated = 86° 35′; ρ measured = 87° 07′, 86° 12′, 86° 45′, 86° 16′, 86° 30′, 86° approximately. All faces gave merely a mass of brightness, and the angles measured represent the center of this mass.

Measurements of S : $\{11.8.\overline{19}.3\}$.

	ϕ		ρ	
	°	′	°	′
Calculated	24	48	79	34
Measured	25	15	78	42
Do	25	35	78	05

The agreement is only approximate, but the faces were so poor that only two out of the six could be even approximately measured.

Angle values for **t** $\{17.16.\overline{33}.1\}$.

	ϕ		ρ	
	°	′	°	′
Calculated	28	59	87	58
Measured	29	27	88	08
Do	28	41	87	51
Do	29	21	87	21
Do	28	26	87	28

Here again the symbol is only approximate. If we change the orientation of the crystal to that given by Goldschmidt in his Winkeltabellen the indices of this last form become $\{49.1.\overline{50}.1\}$, and it is not possible to say they should not be, for instance, $\{50.1.\overline{51}.1\}$, etc. Even in the orientation here taken, the average of the four measured angles agrees well for a number of forms.

Measured and calculated angles of **t**.

	ϕ		ρ	
	°	′	°	′
Average of 4 measured angles	28	59	87	42
Calculated for $17.16.\overline{33}.1$	28	59	87	58
Calculated for $16.15.\overline{31}.1$	28	56	87	50
Calculated for $15.14.\overline{29}.1$	28	52	87	41

However, though the correct indices could not be determined, we have here a form with indices near one of those given above and still too far removed from the prism *a* $\{11\bar{2}0\}$ to be referred to that form. The writer could find no form for calcite approximating that just given, and the form would seem to be new, though it can not be definitely determined.